STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: THREE MOMENT EQUATION

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

بسم الله الرحمن الرحيم

3 Moment Equation

طريقة تستخدم لحل المنشآت الغير محددة استاتيكيا

- كمرات مستمرة Continuous beam
- إطارات Frames

تحت تأثير

① الأحمال Loads .

② الهبوط Settelement

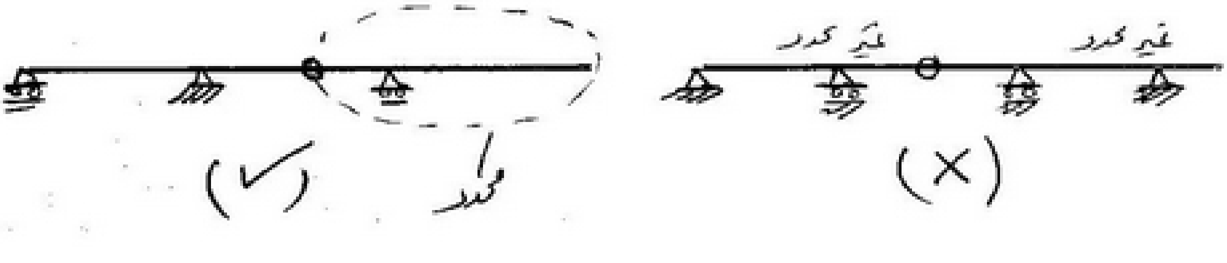
لا تستخدم في حالة تأثير الحرارة

خصائص المنشآت التي يتم حلها باستخدام هذه الطريقة

1 - كل باكية لها Inertia مستمرة ثابتة مع الباكية

يعني عدم وجود (prizmatic Member)

② عدم وجود (Intermediate Hinge) تفصل المنشأ إلى 2 جزئية كل منها غير محدد استاتيكيا .



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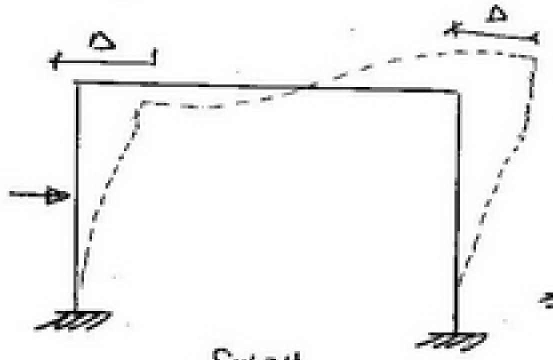
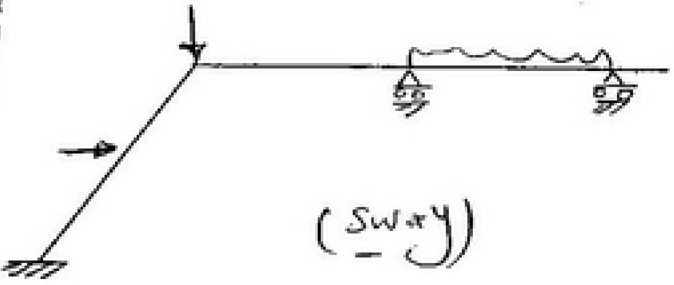
② لا يحدث تشكل side sway ازاحة جانبيه .



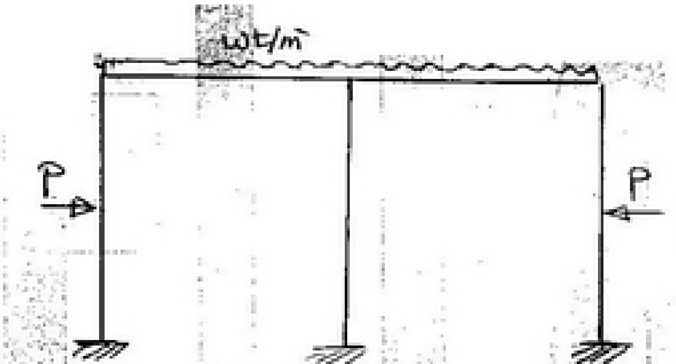
Sway

(X)

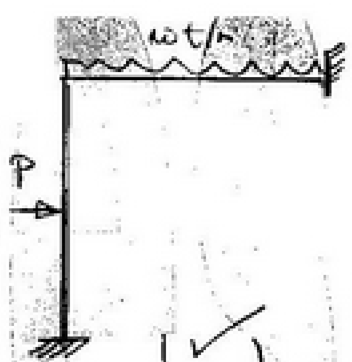


(Sway)

(X)

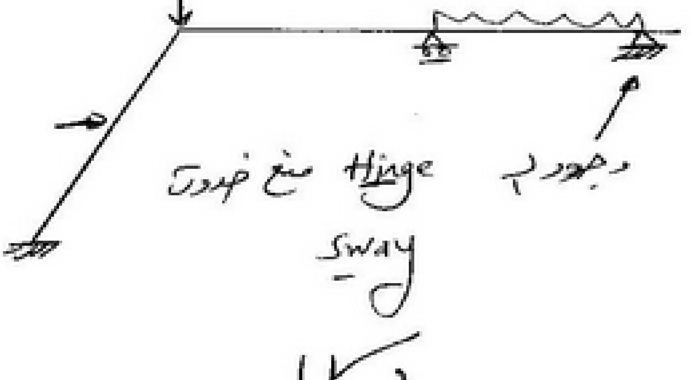


Equal =



(✓)

(✓) Sway التماثل منع حدوث



موجود Hinge منع حدوث

Sway

(✓)

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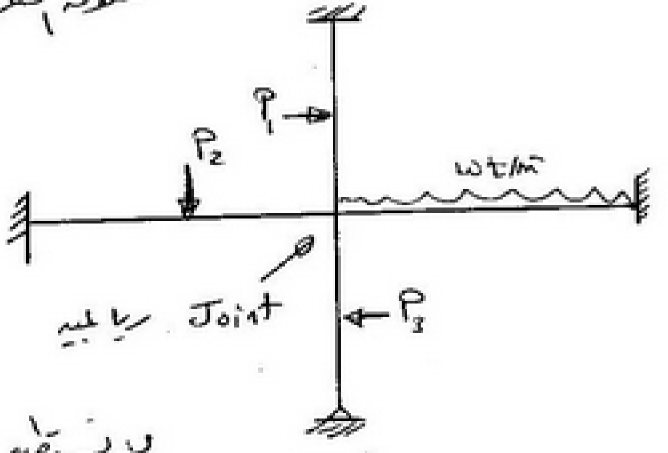
④ عند الـ Joint الواحد لا يوجد أكثر من عزمين غير معلومين و عند الـ Joint المشترك لا بد وأن تكون معلومة العزم من ناحية واحدة



(X)

لا نستطيع تطبيق معادلة الـ 3M في هذه الحالة

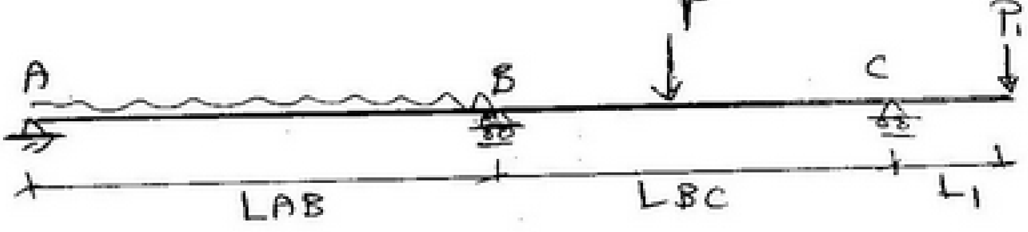
⑤ يمكن استخدام الطريقة عند وجود spring كركيزة بالساند

المطلوب رسم الـ Straining Actions

- N.F.
- S.F.
- B.M.

نتيجة للأحمال المختلفة والهبوط

الخطوات



① حدد المجاهيل (العزوم عند الركائز)

$M_B = \text{Unknown}$

$M_A = \text{Zero}$ و $M_C = -P_1 L_1$

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② حدد العزم الغير معلوم عن طريق وضع (Intermediate Hinge) عند الركيزة (B) وبالتالي تصبح كل باكية (Span) عبارة عن (simple bem)

③ إرسم العزم على كل باكية .

④ حول العزوم إلى أحمال مرنة عن طريق قسمة مساحة العزوم على (EI)

⑤ أوجد رد الفعل المرن الناتج عن الأحمال المرنة عند الركيزة غير معلومة العزم

⑥ صيغة معادلة الـ 3Moment

at (B)

$$M_A\left(\frac{L_{AB}}{I_{AB}}\right) + 2M_B\left(\frac{L_{AB}}{I_{AB}} + \frac{L_{BC}}{I_{BC}}\right) + M_C\left(\frac{L_{BC}}{I_{BC}}\right) = -6r_B$$

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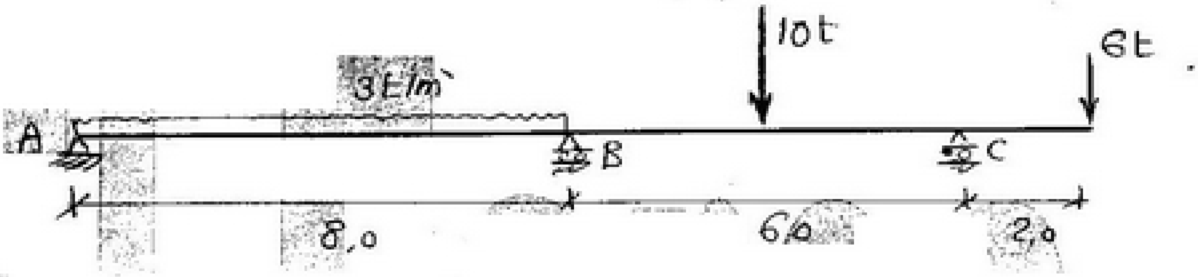
٧ حل الفارس استخرج قيمة العزم عند الركيزة (B) وارسم العزم النهائي ومنه . ارسم الـ free body diagram

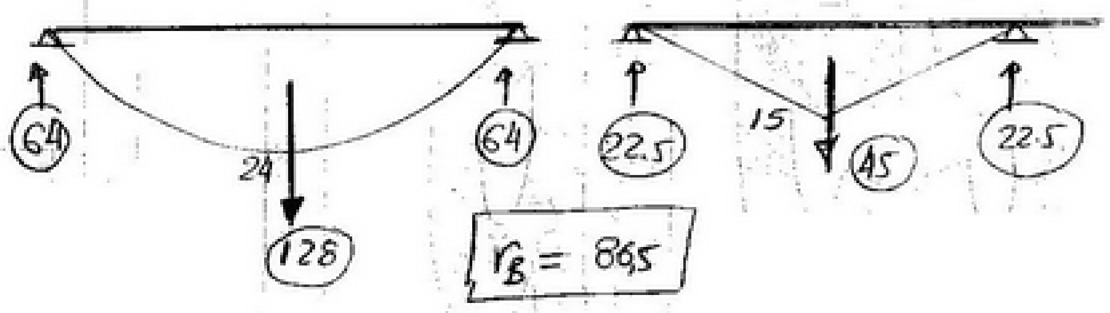
وارسم الـ S.F.D

EX ①

Draw S.F.D, B.M.D using Three Moment Equ.



Sol.



$r_B = 86.5$

at (B)

$$M_A(8) + 2M_B(8+6) + M_C(6) = -6 * 86.5$$

$M_A \rightarrow 0.0$, $M_C \rightarrow -12$

$$28 M_B - 12 * 6 = -519$$

$$M_B = -15.96$$

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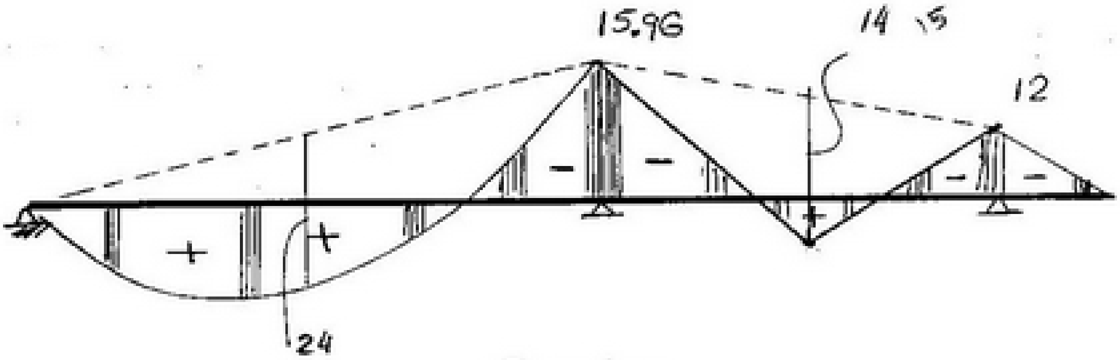
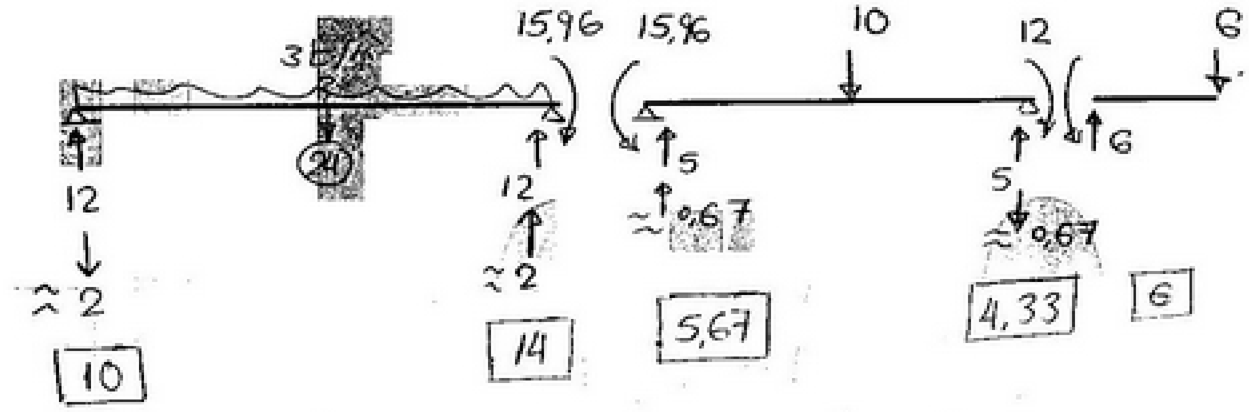
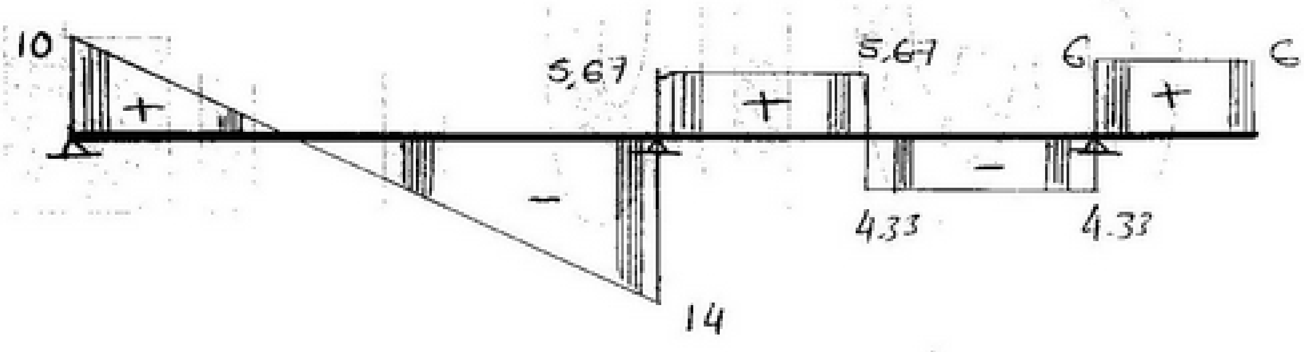


B.M.D





S.F.D

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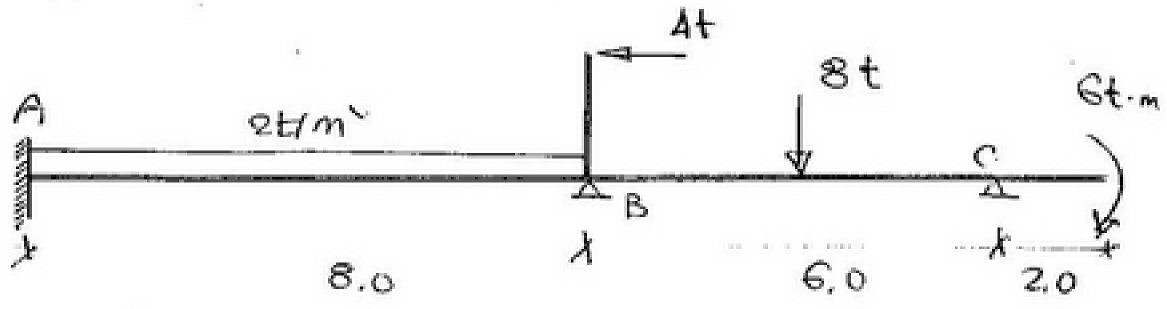
EX ② Draw S.F.D, B.M.D for the Shown str



Sol:

① في حالة وجود **fixed**

نتخيل وجود ركيزة (Ao) تكون العزم عندها = صفر وتكون الـ Inertia لها = ∞ حتى تتم تطبيق المعادلة بطريقة صحيحة.

② في حالة وجود عزم مركز عند ركيزة مثل الـ Joint (B)
نلاحظ أن الـ Joint(B) عبارة عن (Joint) ثلاثية
ولذا قيمة العزم عند أعلى مجهولة من ناحيتيه اليمنى واليسرى

③ يتم تحريك العزم عند الـ Joint لذا يتم الاختيار بين وضع العزم يمين أو وضعه يسار. مع مراعاة الـ (Intermediate Hinge)
أن العزم الذي تم تحريكه هو الذي سيتم الحصول عليه بالمعادلة.

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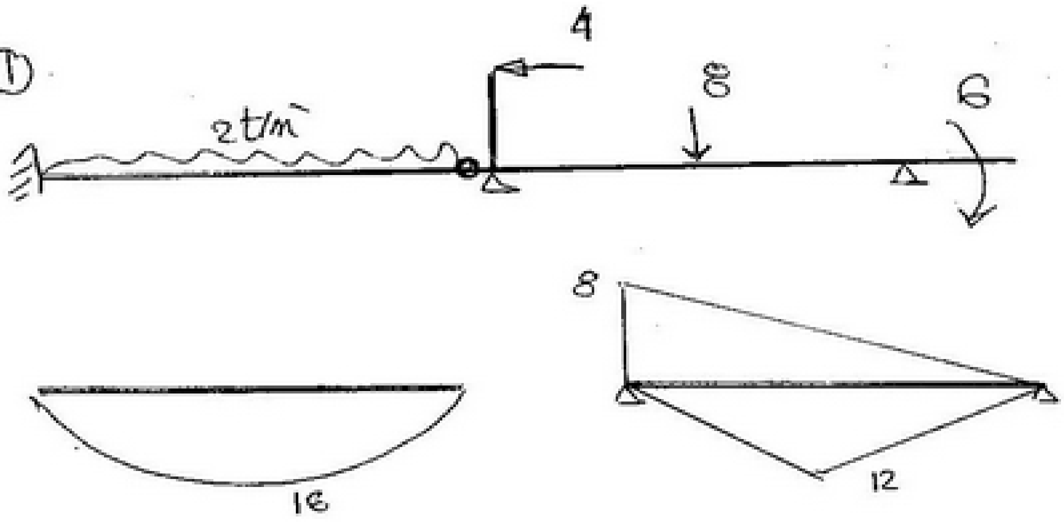
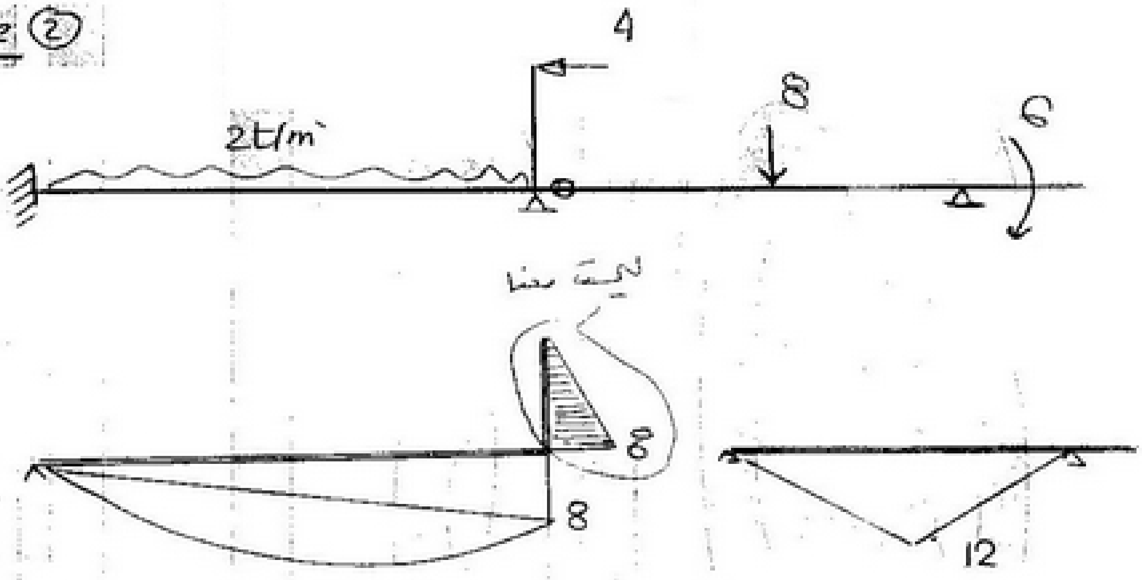
Case ①



Case ②

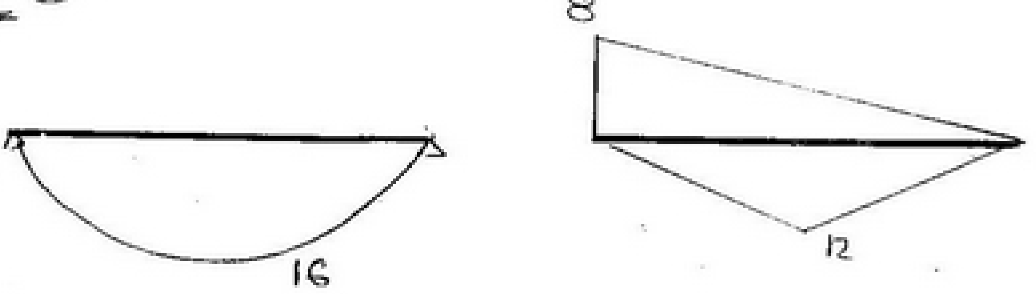


يتم استخدام أى Case منهم مع ملاحظة أن العزم الناتج من

المعادلة هو قيمة العزم عند المكان الموضح بدل Inter_Hing

Case ①

B.M.D



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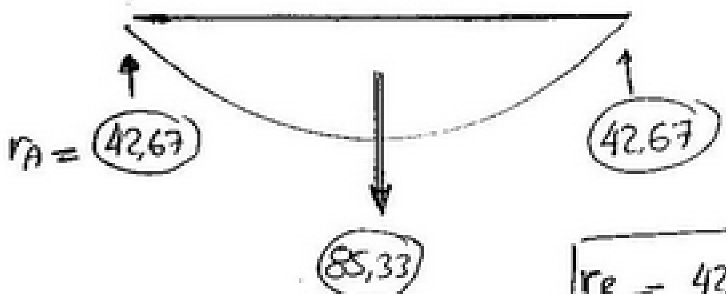
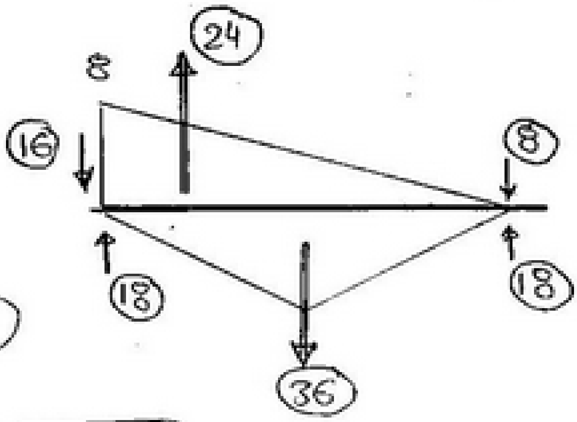
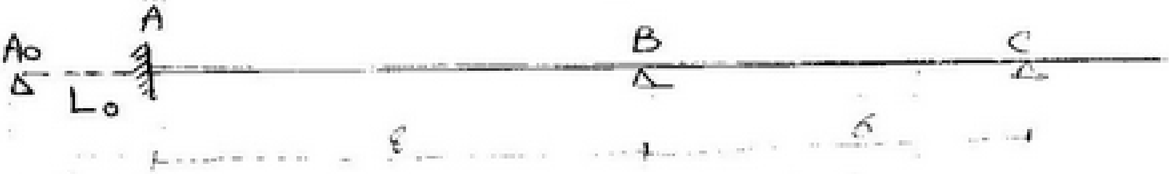




$r_B = 42.67 + 18 - 16$

$r_B = 44.67$

Unknowns M_A, M_B



at (A)

$$M_{A_o}(L_o) + 2M_A(L_o + 8) + M_B(8) = -6r_A$$

($M_{A_o} \rightarrow 0.0$, $L_o \rightarrow 0.0$)

$$16M_A + 8M_B = -6(42.67) = -256 \quad \text{Eq (1)}$$

at (B)

$$M_A(8) + 2M_B(8+6) + M_C(6) = -6r_B$$

($M_C \rightarrow -6$, $r_B \rightarrow 44.67$)

$$8M_A + 28M_B = -232 \rightarrow \text{Eq (2)}$$

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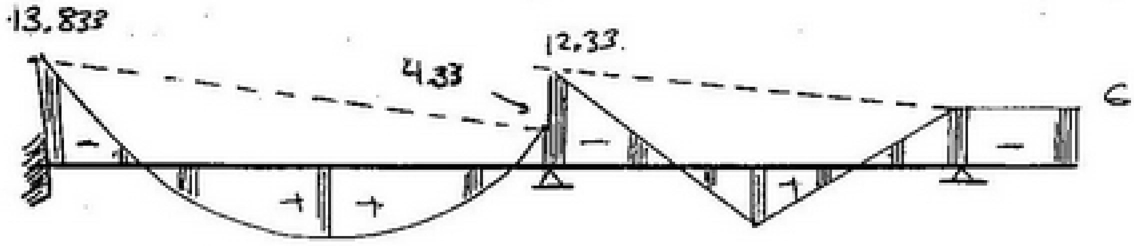
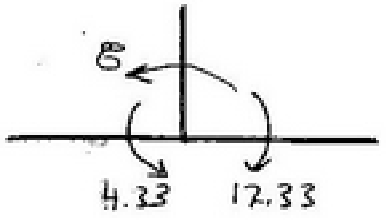
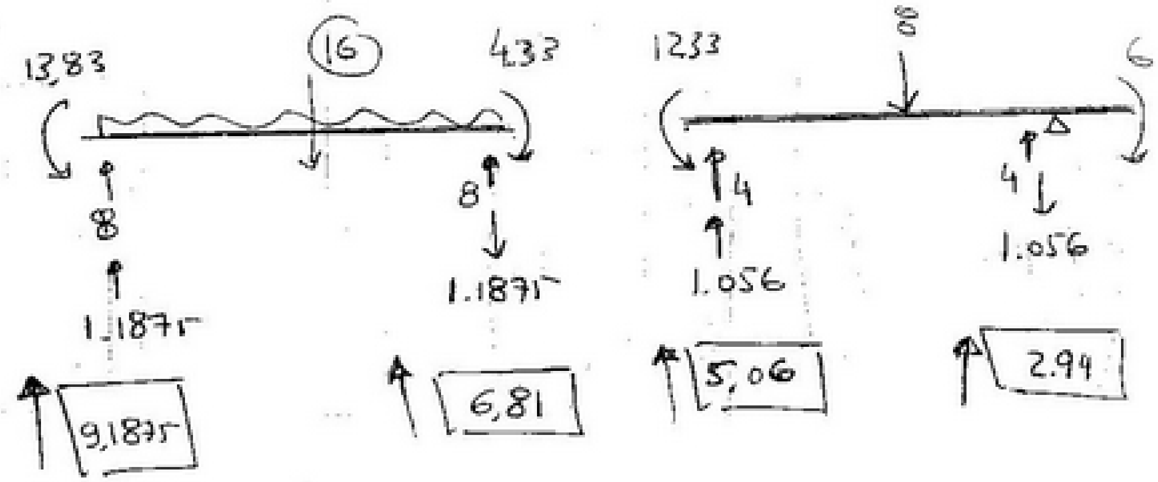
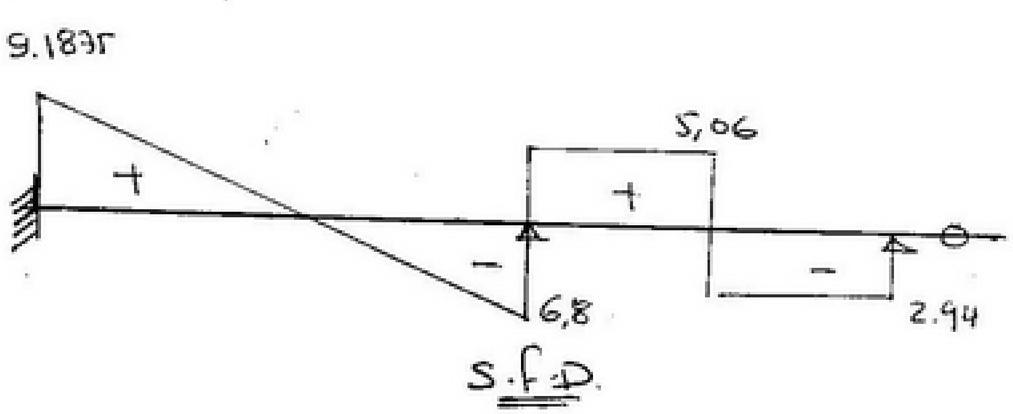


B.M.D



Free body diagram





S.F.D.

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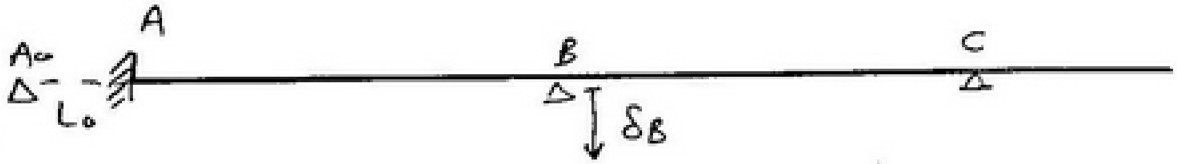
Case of Settelement

الهبوط



اذا تم حل المسألة نتيجة الهبوط نلاحظ اننا نزيل كل الاحمال

ويتم التعويض في نفس معادلة الـ 3M مع تغيير R.H.S (الطرف الايمن)

<u>at (A)</u>

$$M_{A_0}(L_0) + 2M_A(L_0+L_{AB}) + M_B(L_{AB}) = 6EI\left(\frac{\delta_A-\delta_{A_0}}{L_0} + \frac{\delta_A-\delta_B}{L_{AB}}\right)$$

<u>at (B)</u>

$$M_A(L_{AB}) + 2M_B(L_{AB}+L_{BC}) + M_C(L_{BC}) = 6EI\left(\frac{\delta_B-\delta_A}{L_{AB}} + \frac{\delta_B-\delta_C}{L_{BC}}\right)$$

حل المعادلات واستخرج M_A ، M_B وارسم العزوم

عبارة عن خطوط مستقيمة

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CH1: THREE MOMENT EQUATION

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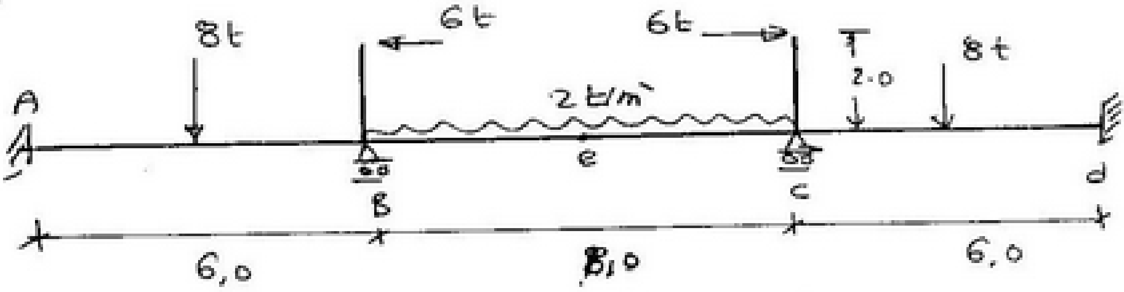
مسألة ٢٠١٢



Draw B.M.D, S.F.D for the shown beam due to

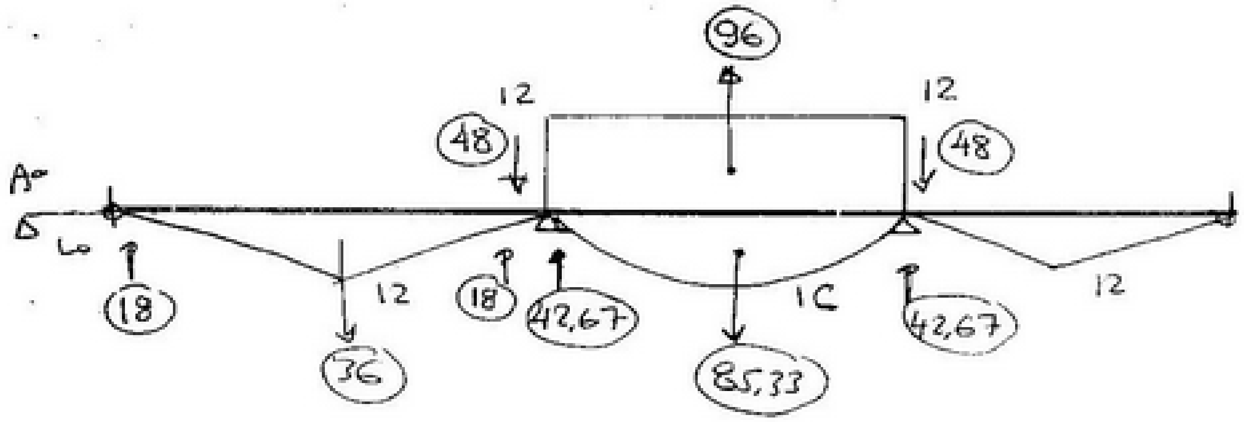
① Given loads

② downward sett at B, C = 1 cm, $EI = 10^4\ t \cdot m^2$

③ Calculate the def at (e)

Sol

① Due to loads



$$r_B = 18 + 42.67 - 48 = 12.67$$

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Unknowns

M_A, M_B, M_C, M_D

From symm $\rightarrow$ $M_A = M_D$

$M_B = M_C$

at (A)

$M_{A_0}(\cancel{I_0}^{0}) + 2M_A(\cancel{I_0}^{0} + 6) + M_B(6) = -6r_A$

$12M_A + 6M_B = -6(r_A)$

$2M_A + M_B = -18 \rightarrow ①$

at (B)

$M_A(6) + 2M_B(6+8) + \cancel{M_C}^{M_B}(8) =$

$-6(r_B)$

$6M_A + 36M_B = -6(12.67)$

$M_A + 6M_B = -12.67 \rightarrow ②$

Solve ①, ②

$M_A = -8.67$

$M_B = -0.667$

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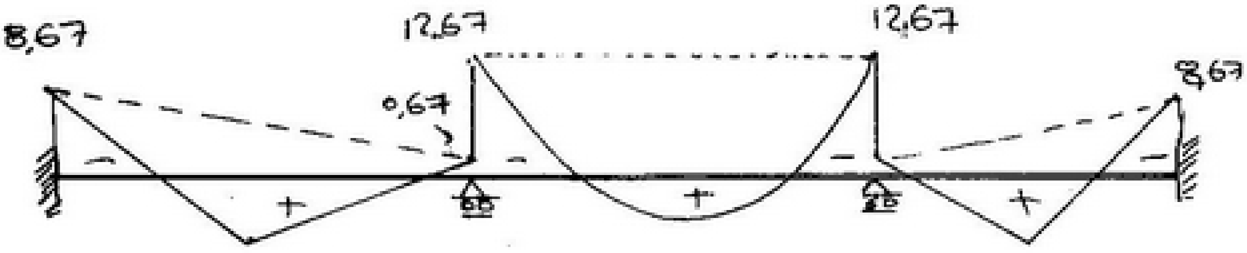
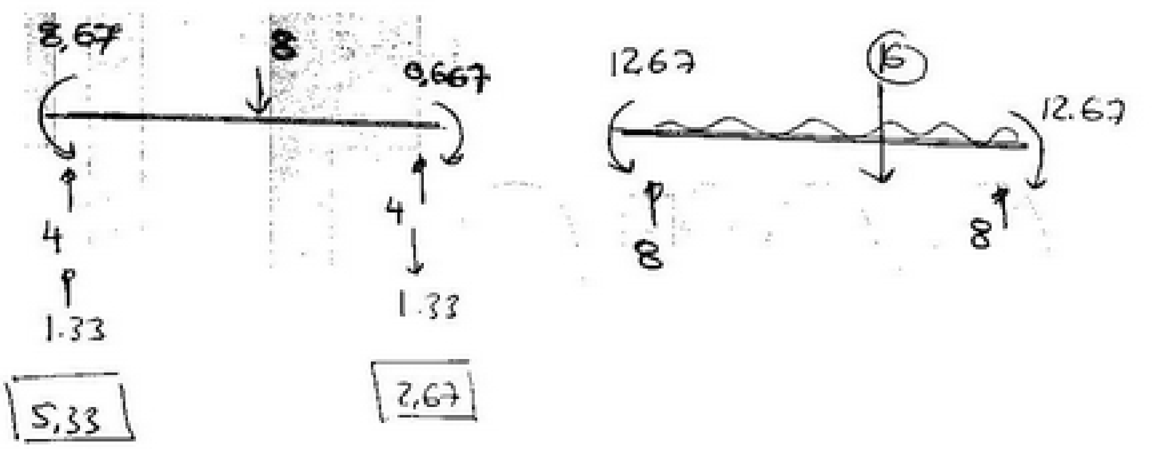
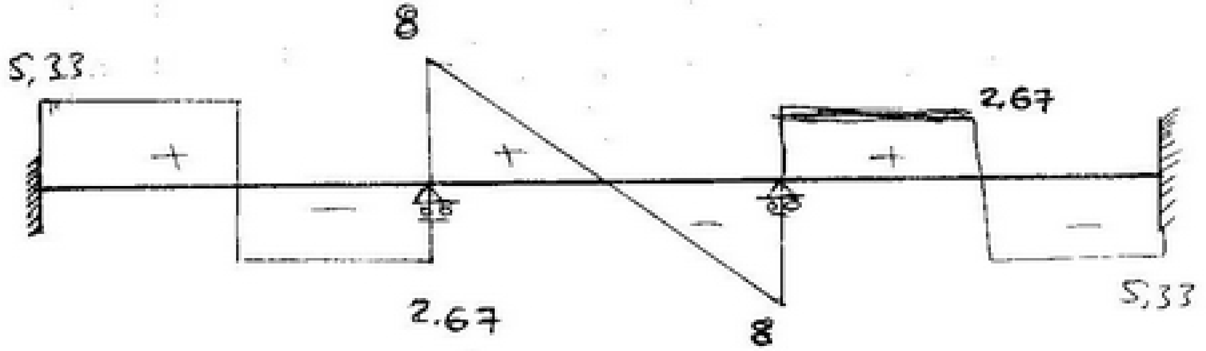


B.M.D





لأحمال متماثلة ← العزم متماثل

← القص shear عكس تماثل

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due to sett at (B, C) = 1cm

حيث يهبط من (B ، C) سم مقداره ١ سم بالتالي .

① انزل كل بنز صال

at (A)

$$M_{A0}(\cancel{L_0}) + 2M_A(\cancel{L_0}+6) + M_B(6) = 6EI\left(\frac{\delta A - \delta A_0}{L_0} + \frac{\delta A - \delta B}{6}\right)$$

(with L_0 → 0)

$$12M_A + 6M_B = 6 * 10^4\left(\frac{0.0 - 0.0}{0.0} + \frac{0.0 - 0.01}{6}\right)$$

$$2M_A + M_B = 10^4\left(\frac{-0.01}{6}\right)$$

$$2M_A + M_B = -16.67 \longrightarrow ①$$

at (B)

$$M_A(6) + 2M_B(6+8) + \cancel{M_C}(8) = 6EI\left(\frac{\delta_B - \delta_A}{6} + \frac{\delta_B - \delta_C}{8}\right)$$

(M_C → M_B)

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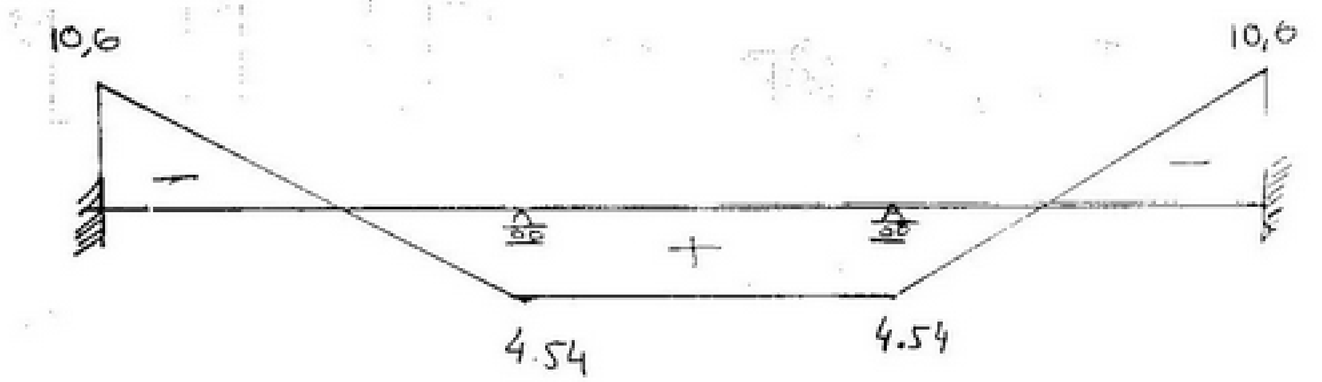
$$6M_A + 36M_B = 6 \times 10^4 \left(\frac{0.01 - 0}{6} + \frac{0.01 - 0.01}{8} \right)$$

$$6M_A + 36M_B = 100 \rightarrow (2)$$

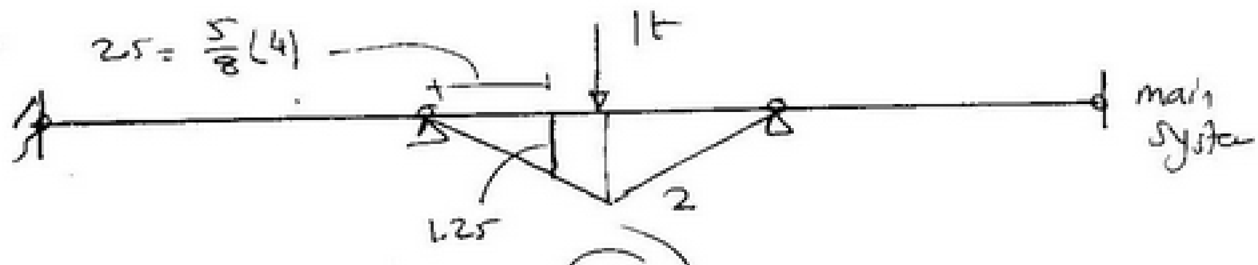
$$M_A = -10.6$$

$$M_B = \underline{\underline{4.54}}$$



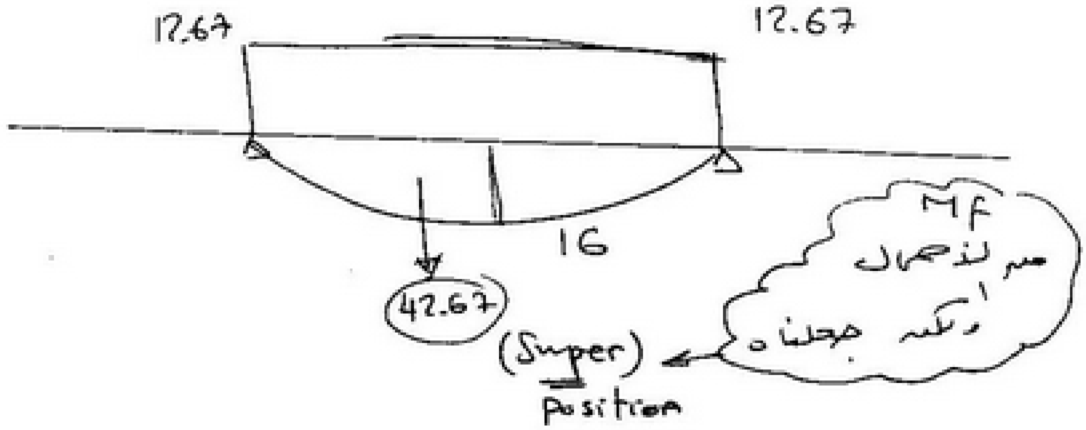
Deflection

يتم تكامل العزوم الناتجة مع العزم الناتج من وضع الحمل
عند النقطة المراد حساب def لها



M_1

def due to loads



$$1 * y_e = \int \frac{M_f M_1}{EJ} dL$$

$$= \frac{1}{EJ} \left(-\frac{1}{2} * 2 * 8 * 12.67 + 2 (42.67 * 1.25) \right)$$

$$= \frac{5.375}{EJ} \downarrow = \underline{\underline{0.053}} \text{ cm}$$

due to sett

$$1 * y_e = \frac{1}{EJ} \left(\frac{1}{2} * 2 * 8 * 4.54 \right)$$

$$= \left(\frac{36.32}{EI} \downarrow \text{ cm} + \text{مقدار الهبوط نفسه} \right)$$

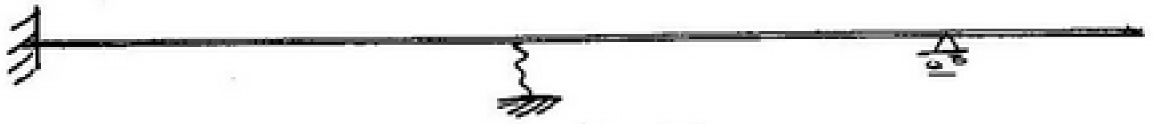
للكمية النهائية

$$\therefore y_e = \left(\frac{36.32}{EJ} + 1 \text{cm} \right)$$

ثم بتكامل العزم الناتج من الهبوط مع العزم الناتج

(1)طب

Case of spring



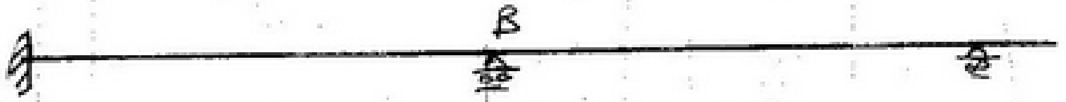
k t/cm

Stiffness of spring = k

Stiff = مقدار القوة اللازمة لهبوط مقدار الوحدة

force per unit displacment

① أزيل الـ spring وضع مكانه roller



② حل عادي ⟵ (M_{F_1}) (Mo) وكون free body diagram

③ أوجد رد الفعل في مكان الـ spring ⟵ (R_0)

④ حل جديد حل نتيجة هبوط في مكان الـ spring مقداره ١ سم ⟵ (M_{F_2}) — M_1

⑤ كون الـ free body وأوجد رد الفعل بمكان الـ spring.

⟵ (R_1)

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titanic_ship1912@yahoo.com

! حيث

$$\Delta = \frac{R_0}{K - R_1}$$

! أولاً نحن حسبنا شيء هبوط مقداره ١٣

ولكن ده مش الهبوط الفعلي تحت الـ spring

∴ Δ = مقدار الهبوط الفعلي من تحت الـ spring.

السالبة في المعادلة عادي ونأخذ (R_1)
بإشارتها.

$$(M_F) = M_0 + \Delta M_1$$

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(3)

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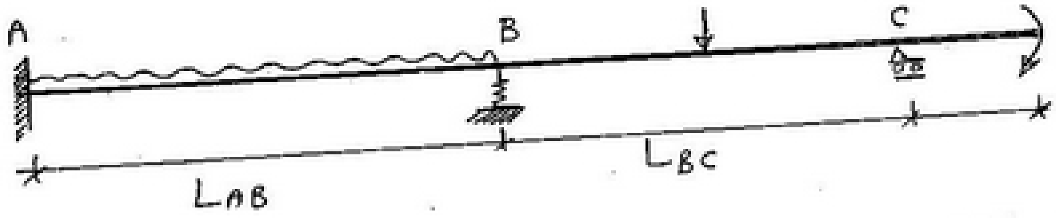
بسم الله الرحمن الرحيم

Three Moment Equation

Case of Spring



معطى عندك الـ spring بـ (k)

k = stiffness of spring

معنى الـ stiffness

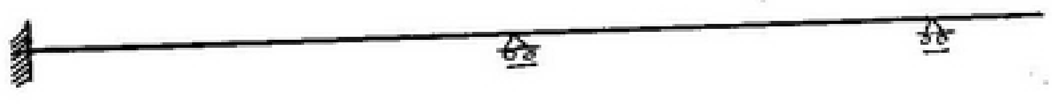
القوة المطلوبة للإزاحة مقدارها الوحدة

force per unit displacement

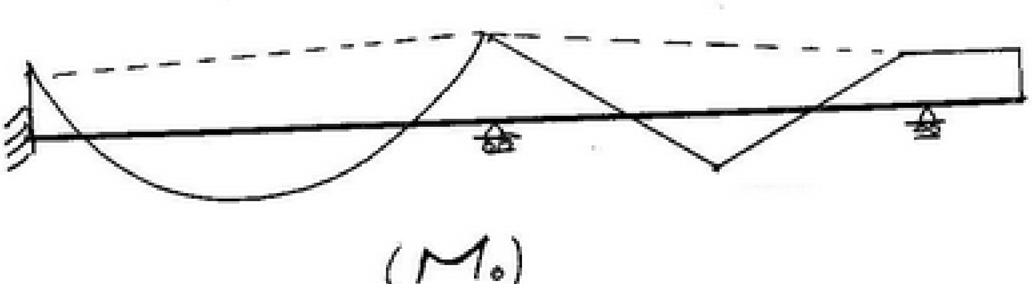
k = stiffness = force per unit displacement

خطوات الحل:

① أزل الـ spring وضع مكانه ركيزة عادية.



② حل عادي نتيجة الأحمال باستخدام الـ 3Moment Equation



(M_0)

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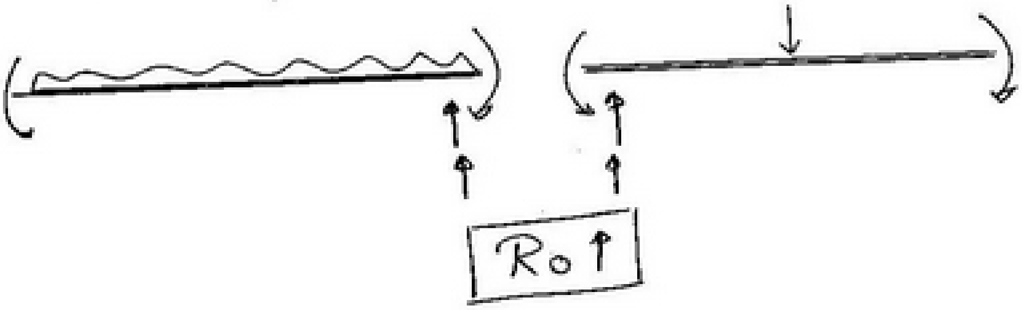
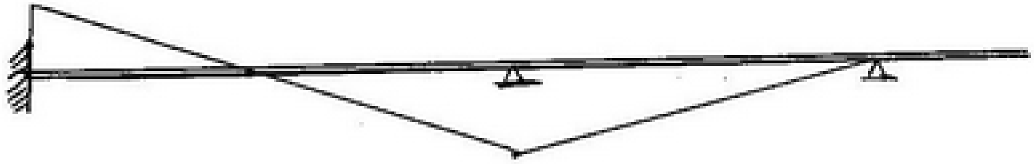
titanic_ship1912@yahoo.com

② العزم النهائى نتيجة الأحمال بعد التعويض عن ال spring باستخدام roller = (M_0) وأوجد رد الفعل عند ال spring = (R_0)

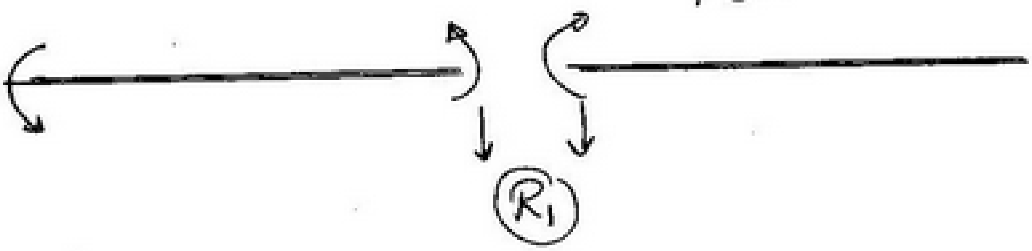


③ حل مرة أخرى نتيجة حدوث هبوط مقداره الوحدة = (١ سم) من مكان ال spring واستخرج العزم النهائى لتكوين (M_1)



(M_1)

④ أوجد رد الفعل عند ال spring



$$\therefore \quad \Delta = \frac{R_0 \uparrow}{K - R_1 \uparrow}$$

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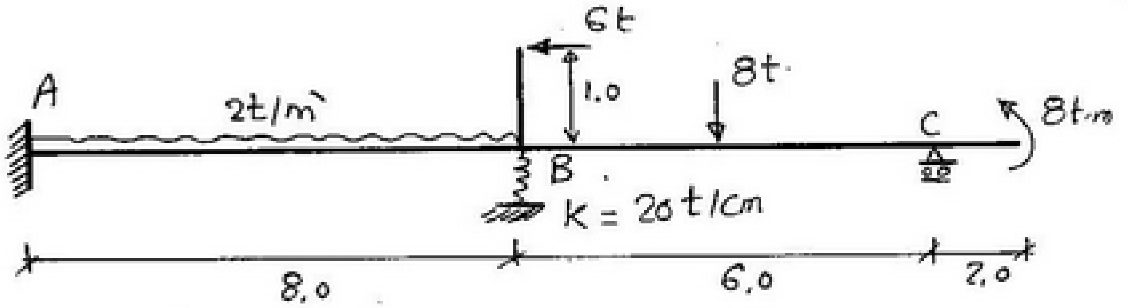
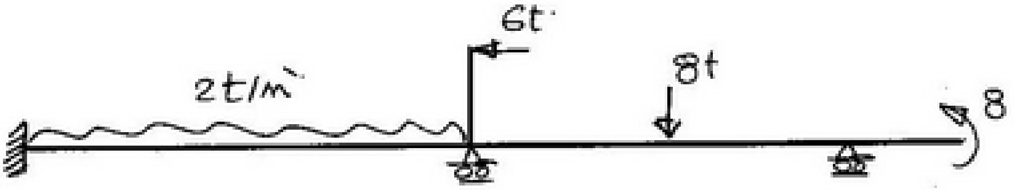
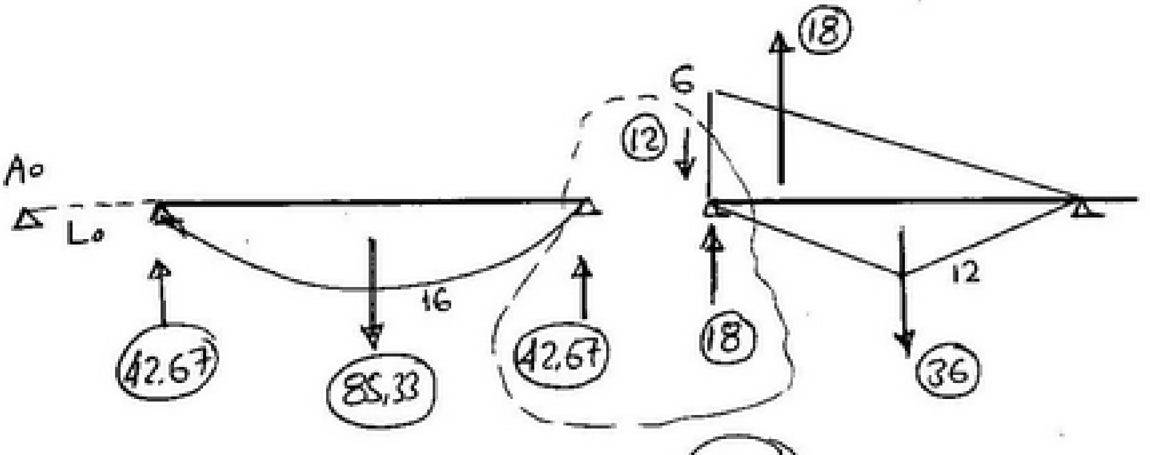
$$\therefore \quad M_F = M_0 + \Delta M_1$$

EX Draw B.M.D, S.F.D for the shown structure.



Sol^n





$r_A = 42.67$ $\qquad$ $r_B = 48.67$

تم تطبيق معادلة لـ 3M Equ عند الأماكن غير معلومة العزوم

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at (A)

$$M_{Ao}(L_o) + 2M_A(L_o + 8) + M_B(8) = -6r_A$$

($M_{Ao}(L_o) \rightarrow 0.0$, $L_o \rightarrow 0.0$)

$$16M_A + 8M_B = -6(42.67) = -256$$

$$\therefore \quad 2M_A + M_B = -32 \longrightarrow (1)$$

at (B)

$$M_A(8) + 2M_B(8+6) + M_C(6) = -6r_B$$

($M_C \rightarrow +8$)

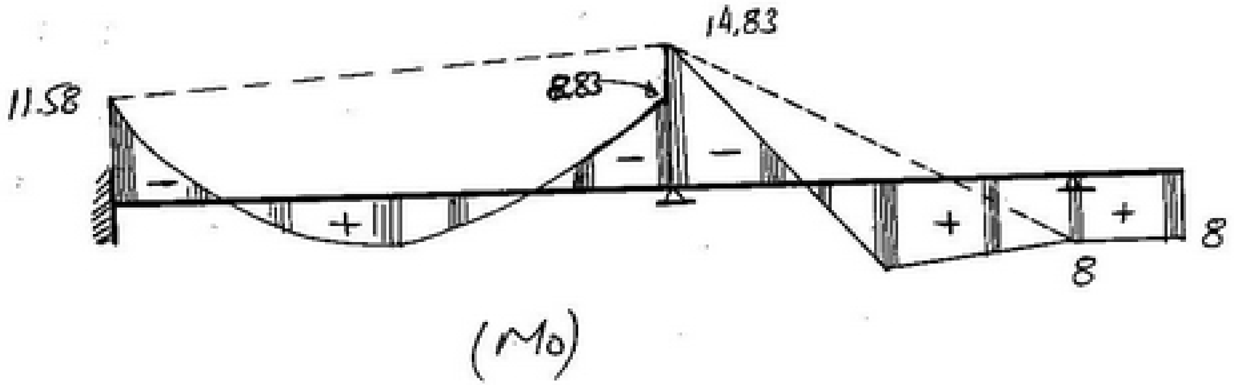
$$8M_A + 28M_B + 48 = -6(48.67)$$

$$\therefore \quad 8M_A + 28M_B = -340 \longrightarrow (2)$$

Solving Equs (1) & (2)

then $M_A = -11.58$

$M_B = -8.83$



(M_o)

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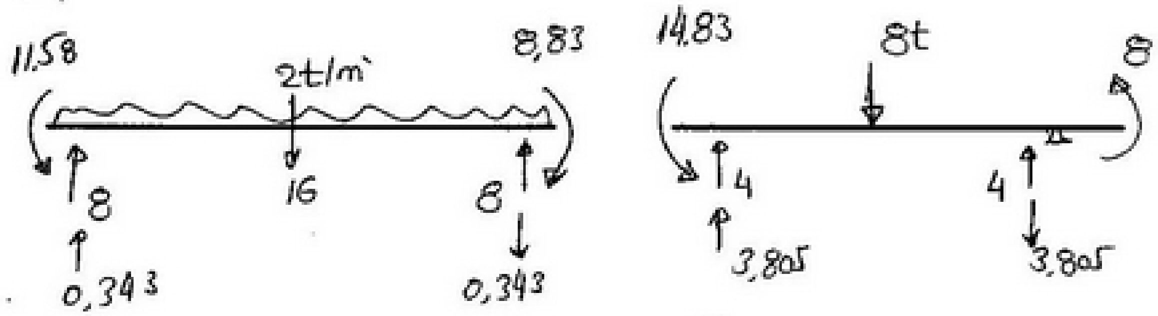
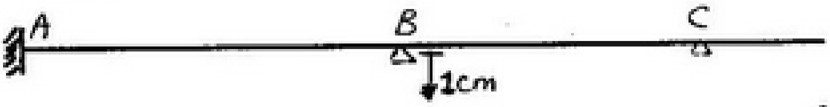


$$R_0 = 15.46$$

again Solve due to settlement at B = 1 cm



at (A)

$$16M_A + 8M_B = 6EI\left(\frac{\delta_A - \delta_{A_0}}{L_0} + \frac{\delta_A - \delta_B}{8}\right)$$

($\delta_A = 0$, $\delta_{A_0}/L_0 = 0$, $\delta_B = 0.01$)

$$\therefore 16M_A + 8M_B = 6*10^4\left(\frac{-0.01}{8}\right) = -75 \rightarrow (1)$$

at (B)

$$M_A(8) + 28M_B + M_C(6) = 6EI\left(\frac{\delta_B - \delta_A}{8} + \frac{\delta_B - \delta_C}{6}\right)$$

($M_C \rightarrow 0.0$, $\delta_A = 0.0$, $\delta_C = 0.0$)

$$8M_A + 28M_B = 6*10^4\left(\frac{0.01}{8} + \frac{0.01}{6}\right) = 175 \rightarrow (2)$$

Solve (1), (2) $\rightarrow$

$$M_A = -9.11$$

$$M_B = 8.85$$

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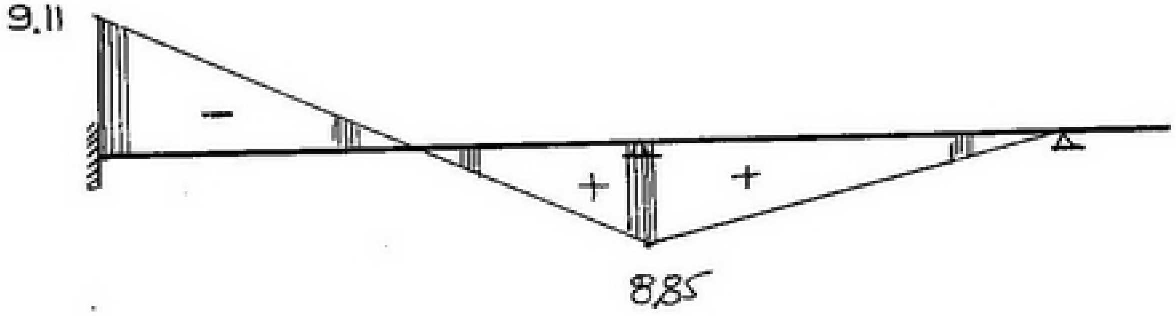
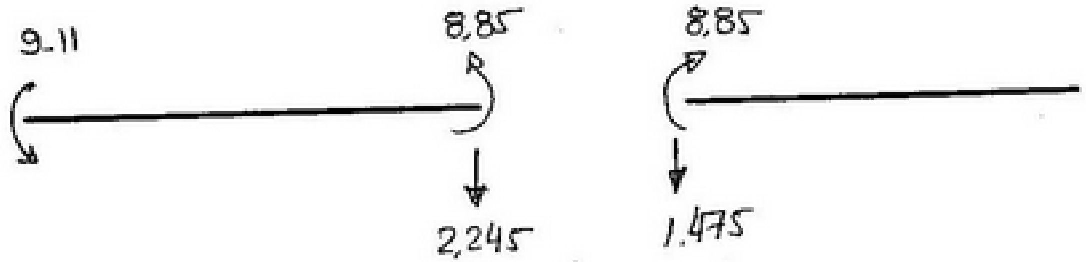
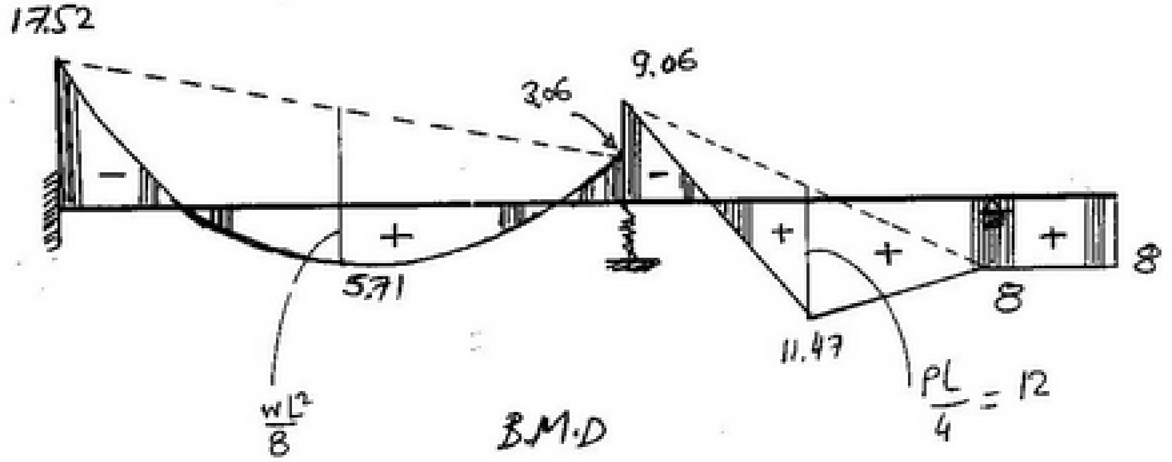




$R_1 = 3.72 \downarrow$

$$\Delta = \frac{R_0}{k - R_1} = \frac{15.46}{20 - (-3.72)} \cong 0,652$$

$$M_f = M_0 + \Delta M_1$$



B.M.D

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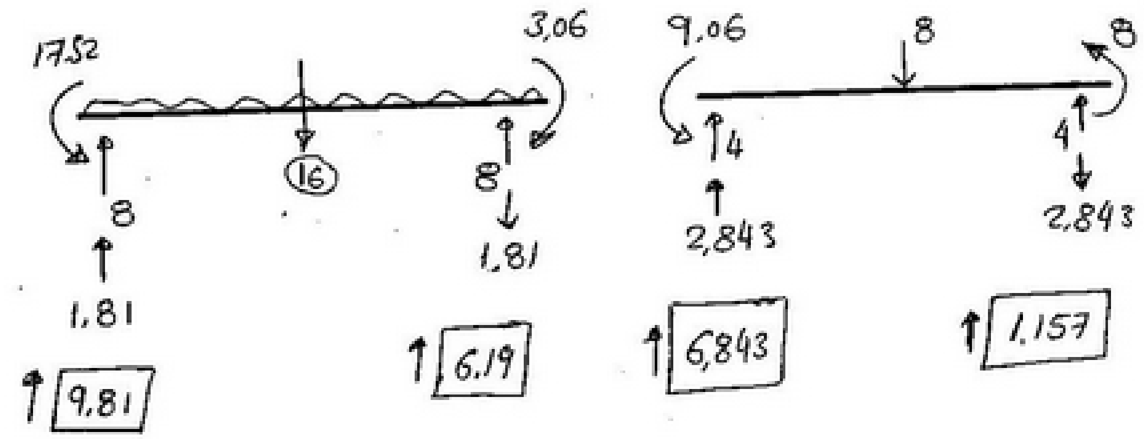
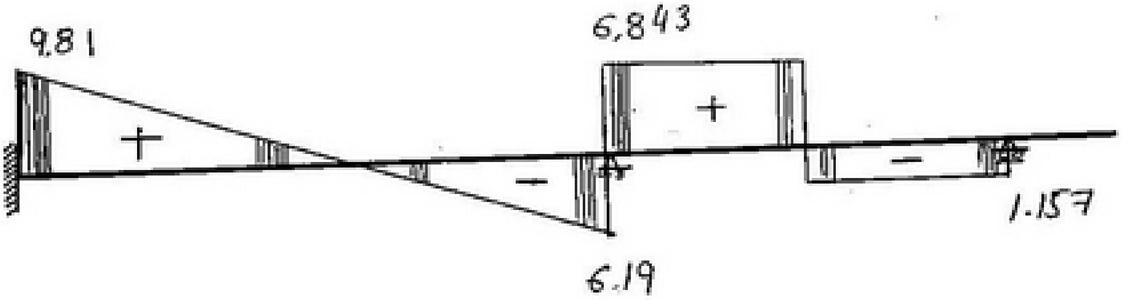


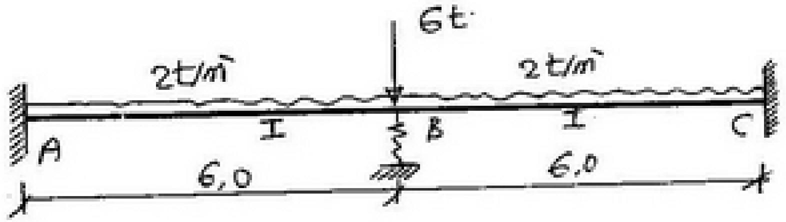


S.F.D

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Ex

$K = 4\ t/cm$

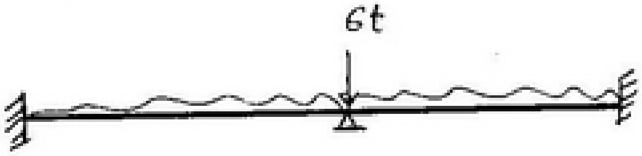


Draw B.M.D, S.F.D due to

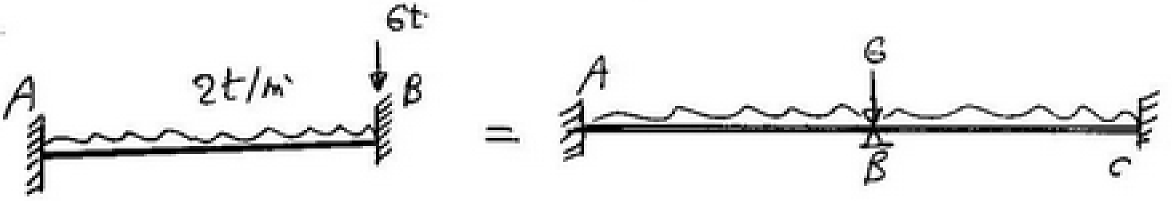
1. Given loads
2. Settelement at A, C = 1cm, $EI = 4800\ t.m^2$

Sol.

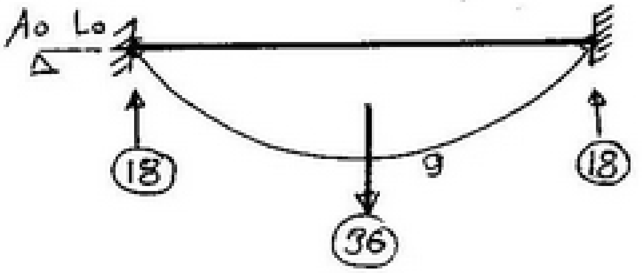
1. Due to given loads



$M_A = M_C$ — المسألة متماثلة سيمترية



$M_A = M_B$



at A

$$M_{A_o}(L_o) + 2M_A(L_o + 6) + M_B(6) = -6(18)$$

($M_{A_o} \to 0.0$, $L_o \to 0.0$, $M_B \to M_A$)

$$\therefore\ 18 M_A = -108$$

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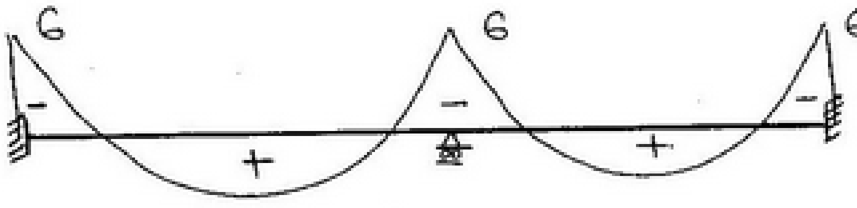
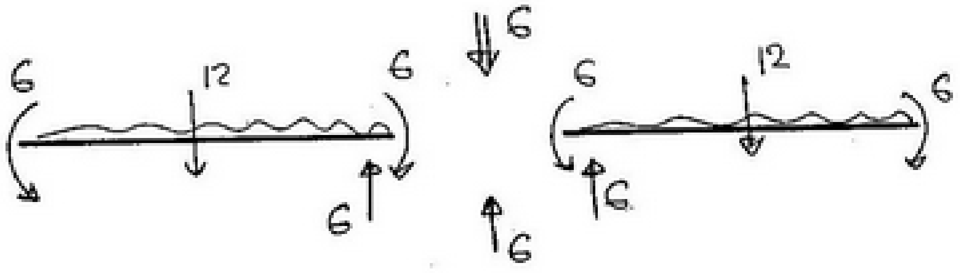
titanic_ship1912@yahoo.com

$$\therefore \quad M_A = -6$$

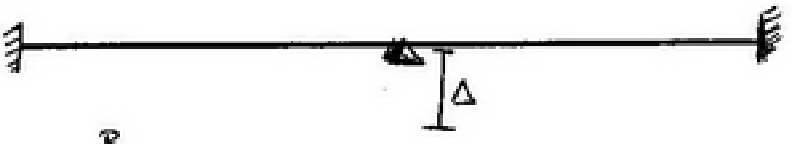


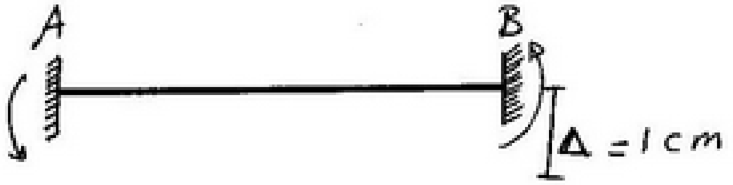
(M_o)



$R_o = 18$

② Due to Settlement at spring = 1 cm ↓





في حالة وجود كمرة fixed-fixed تكون العزم نتيجة الهبوط

$$M = \frac{6\,E.I\,\Delta}{L^2}$$

أو نتيجة عادي جداً بتقسيم لـ (3M) عند الركيزة (A) وكذلك (B)

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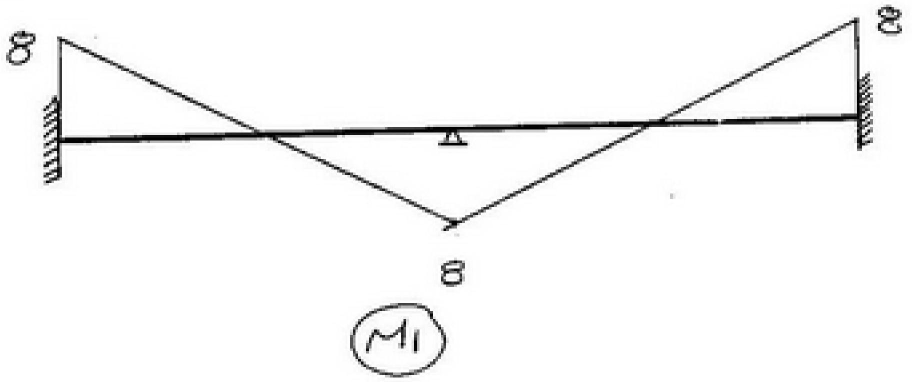
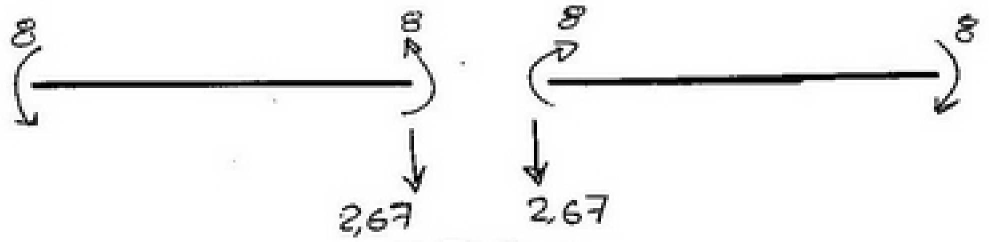
$$\therefore \frac{6EI\Delta}{L^2} = \frac{6 * 4800 * 0.01}{(6)^2} = 8$$

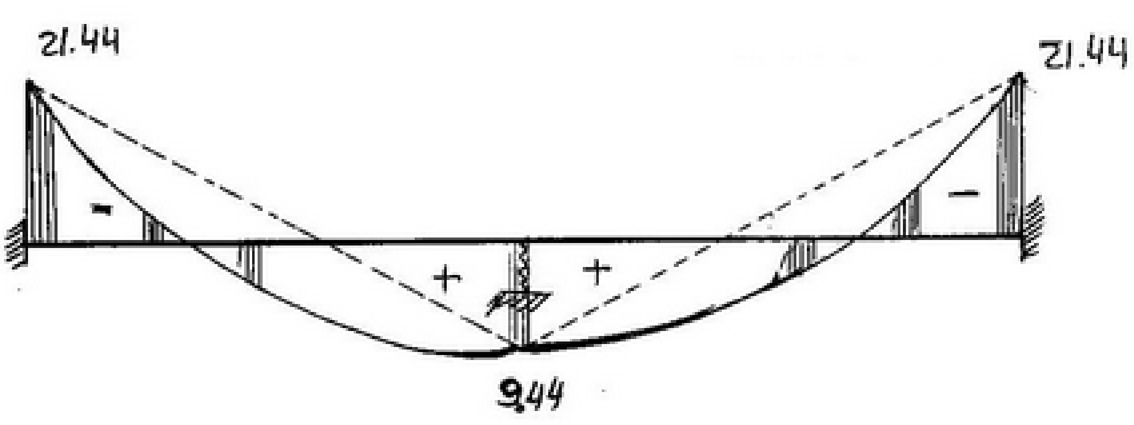




$R_1 = 5,33$

$$\Delta = \frac{R_0}{K - R_1} = \frac{18}{4 - (-5,33)} = 1,93 \text{ cm}$$

$$M_f = M_0 + \Delta M_1$$



B.M.D

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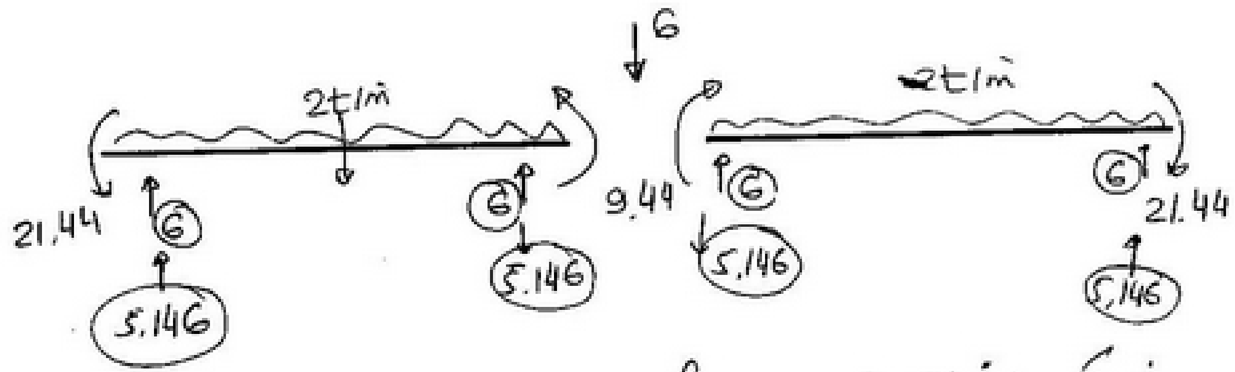
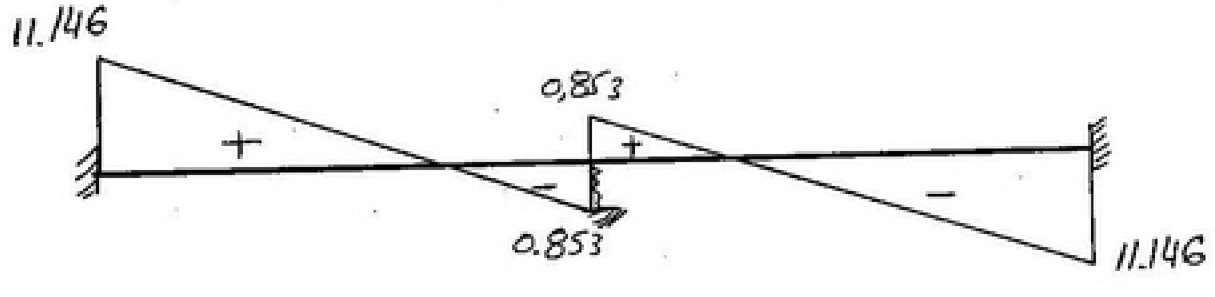


11.146

أو عكيد إخراج ب S.F.D

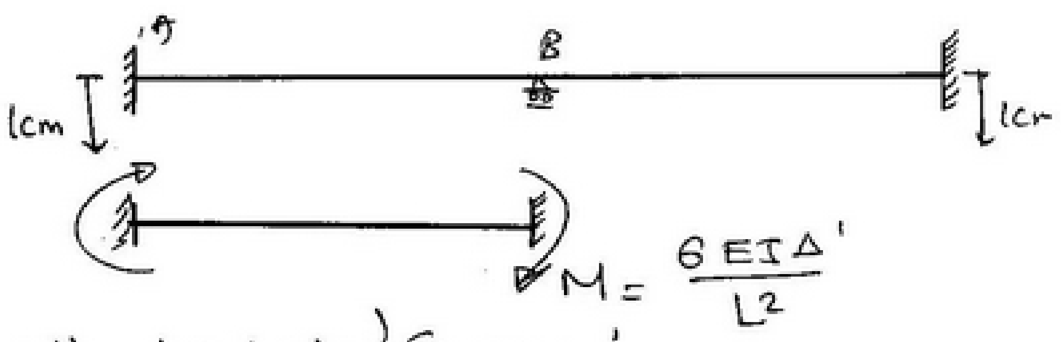
$$S.f = (S.f)_0 + \Delta (S.f)_1$$



(S.F.D)

Case of settlement at A, C = 1cm

لاحظ أننا سنحل مرتين مرة نتيجة حدوث هبوط مقداره ١ سم
عند الركيزتين (A & C) ووضع ركيزة عادية عند B Spring
وثانية نحل مرة جديدة نتيجة حدوث هبوط مقداره ١ سم عند B Spring.



$$M = \frac{6EI\Delta'}{L^2}$$

أو نقوم بتطبيق معادلة (3M)

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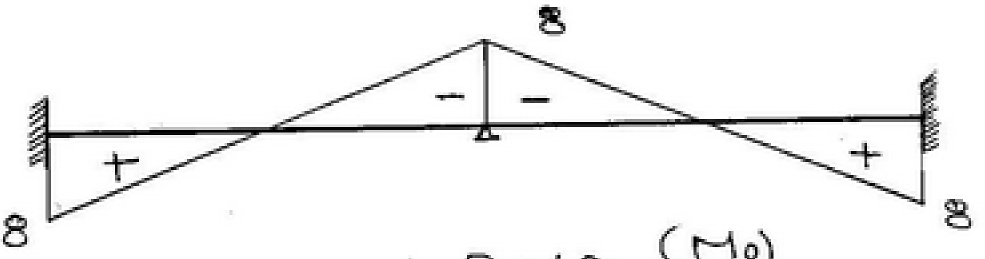
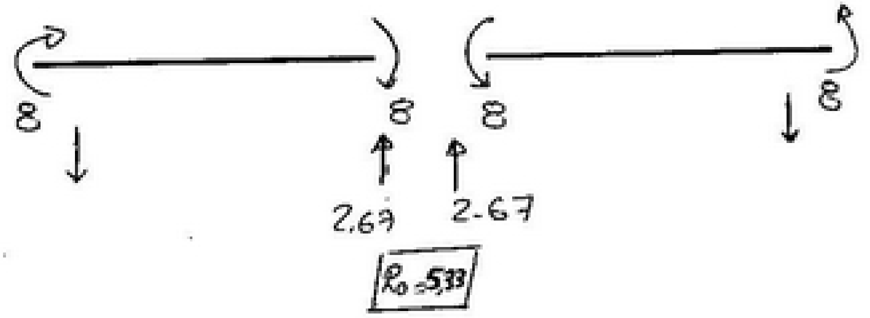
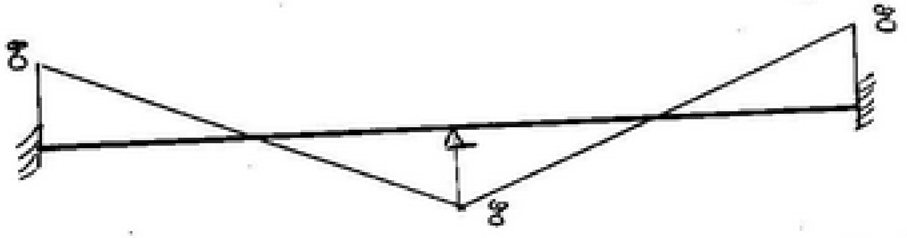


B.M.D (M_0)

due to



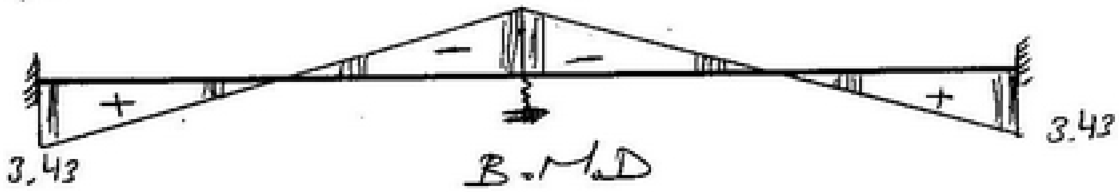
② due to settelement at B = 1cm



(M_1) , $R_1 = 5.33 \downarrow$

$$\Delta = \frac{R_0}{k - R_1} = \frac{5.33}{4 - (-5.33)} = 0.571$$

$M_f = M_0 + \Delta M_1$



B.M.D

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titanic_ship1912@yahoo.com

STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: THREE MOMENT EQUATION

(4)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

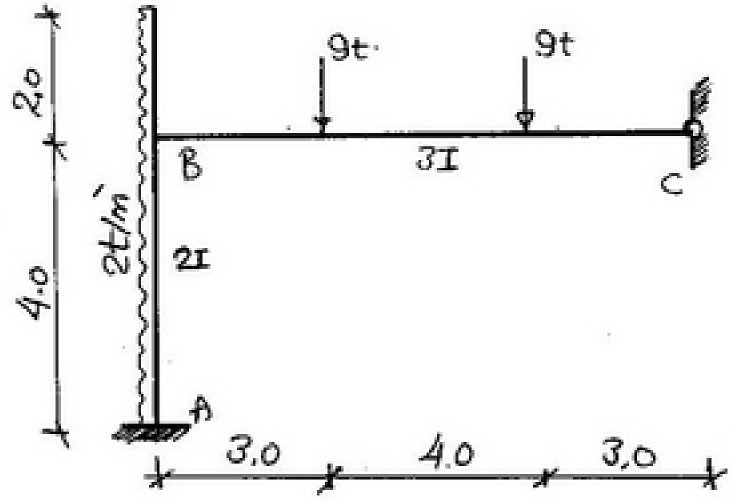
(Three Moment Equation)

Frames

Draw B.M.D, S.f.D, N.f.D due to

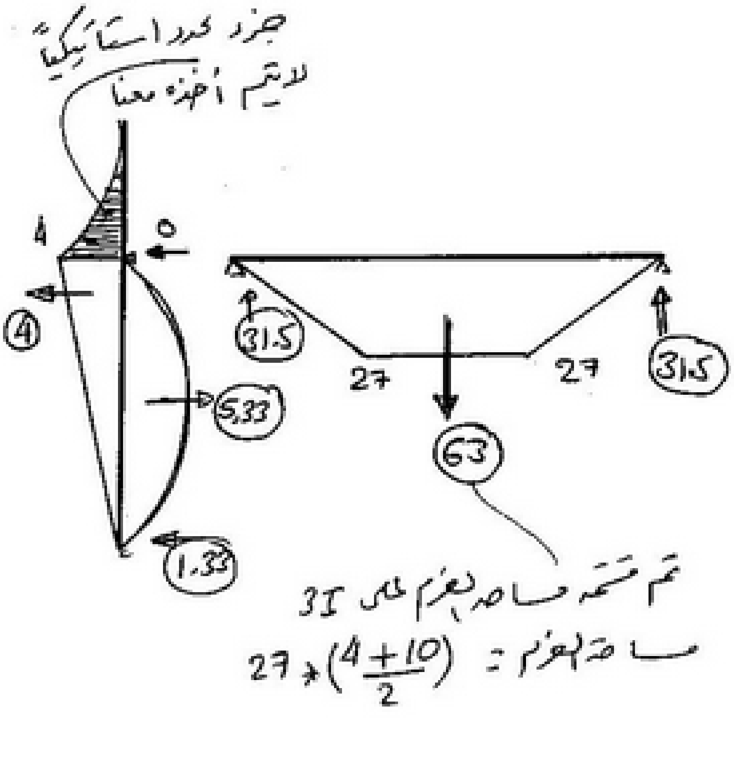
① Given Loads

② Sett at A = 2cm , $EI = 20,000\ t.m^2$



1 (Due to loads)

يتم حساب العزم الناتج
من الجزء المحدد استاتيكية
وعدم تركيزه من الجزء الخاص
به .



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Unknowns M_A , M_B

at A

$$M_A \left(\frac{l_0}{\ }\right) + 2M_A\left(\frac{1}{0} + \frac{4}{2}\right) + M_B\left(\frac{4}{2}\right) = -6\,r_A$$

($M_A (l_0) \to 0.0$, $\frac{1}{0} \to 0.0$, $2I \to \frac{4}{2}$)

$$4M_A + 2M_B = -6 \times 1.33 = -8 \to (1)$$

at (B)

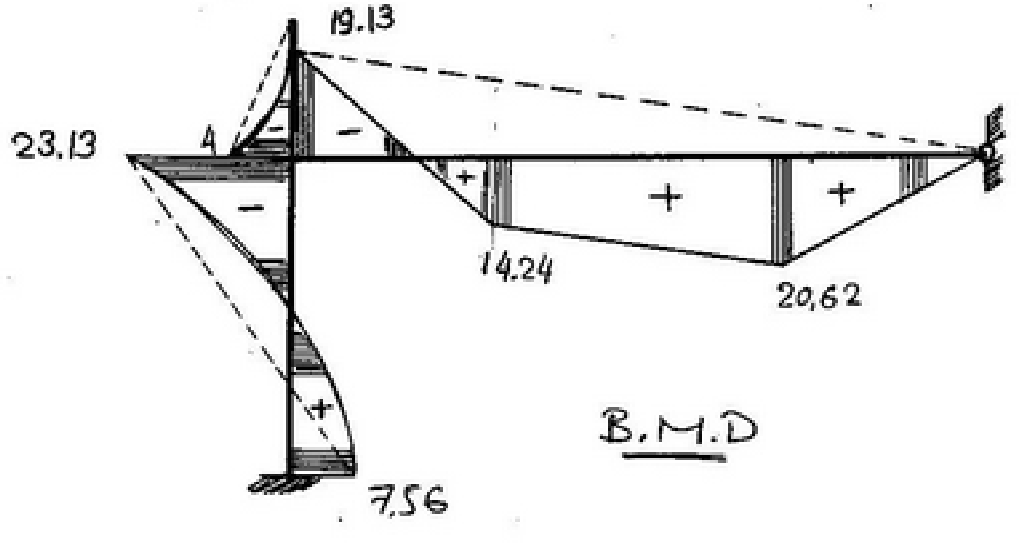
$$M_A\left(\frac{4}{2}\right) + 2M_B\left(\frac{4}{2} + \frac{10}{3}\right) + M_C\left(\frac{10}{3}\right) = -6\,r_B$$

($M_C \to 0.0$)

$$2M_A + 10.67\,M_B = -6\,(31.5) = -189 \to (2)$$

Solve (1), (2) Get $M_A = +7.56$

$M_B = -19.13$



B.M.D

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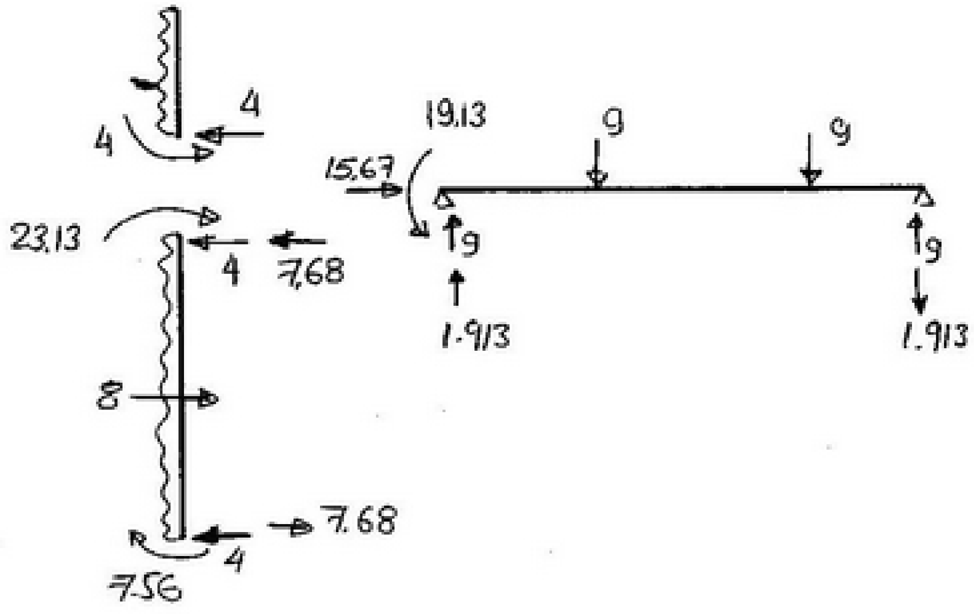

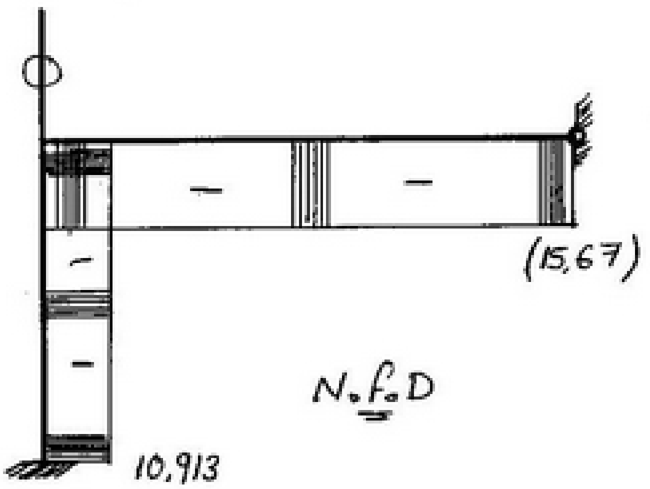

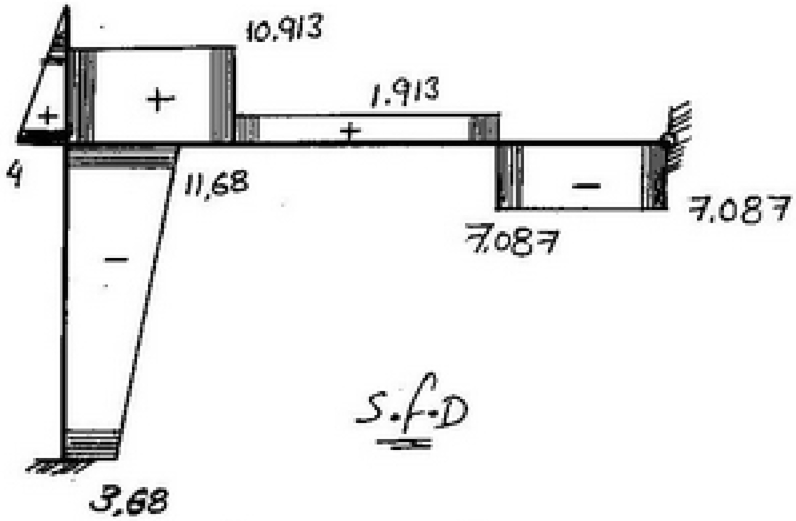

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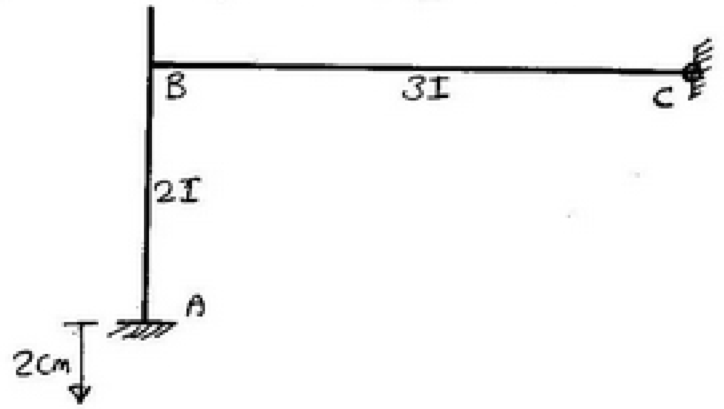
Due to settelement at A = 2 cm

ملحوظة هام جداً

هنا الهبوط العمودي على العضو أثناء التطبيق من معادلة
الـ (3M) وهو المسئول عنه إيجاد العزوم.



at (A)

$$2M_A\left(\frac{4}{2}\right) + M_B\left(\frac{4}{2}\right) = \text{Zero}$$

$$= 6EI\left(\frac{\delta_A - \delta_{A0}}{L_0} + \frac{\delta_A - \delta_B}{4}\right)$$

$$4M_A + 2M_B = 0.0 \rightarrow (1)$$

at (B)

$$M_A\left(\frac{4}{2}\right) + 2M_B\left(\frac{4}{2} + \frac{10}{3}\right) + \cancel{M_C}^{\,0.0}\left(\frac{10}{3}\right) =$$

$$6EI\left(\frac{\delta_B - \delta_A}{4} + \frac{\delta_B - \delta_C}{10}\right)$$

$$2M_A + 10.67 M_B = 6 * 20000\left(\frac{\overset{0}{\cancel{\delta_B}} - \overset{0}{\cancel{\delta_A}}}{4} + \frac{\overset{0.02}{\cancel{\delta_B}} - \overset{0}{\cancel{\delta_C}}}{10}\right)$$

$$2M_A + 10.67 M_B = 6 * 20000\left(\frac{0.02}{10}\right) = 240 \rightarrow (2)$$

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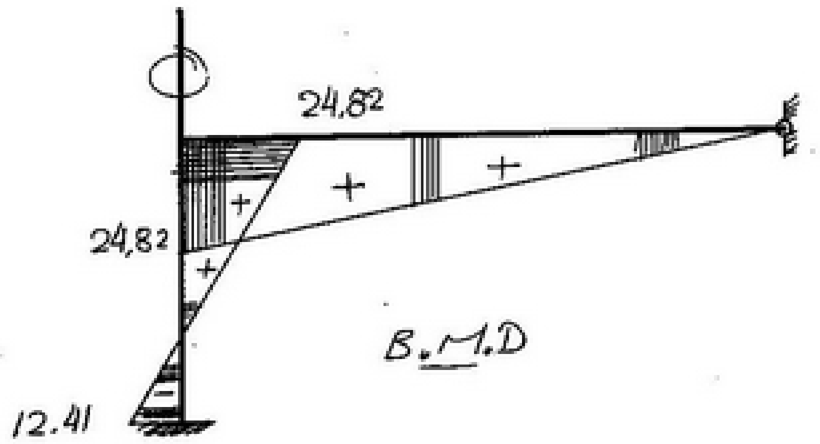
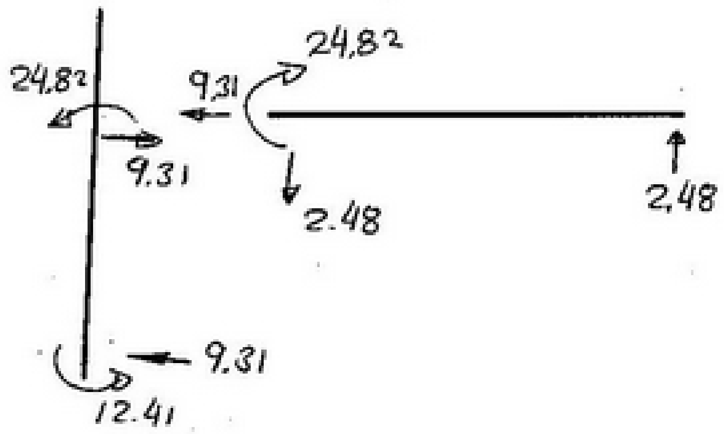
titanic_ship1912@yahoo.com

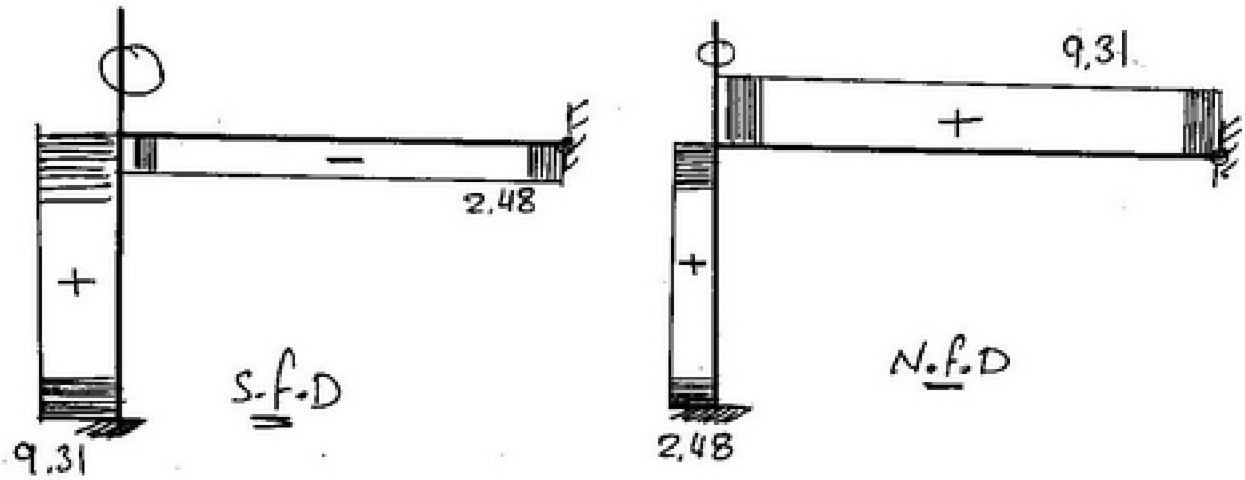
Solve ①, ②

$$M_A = -12.41$$

$$M_B = +24.82$$







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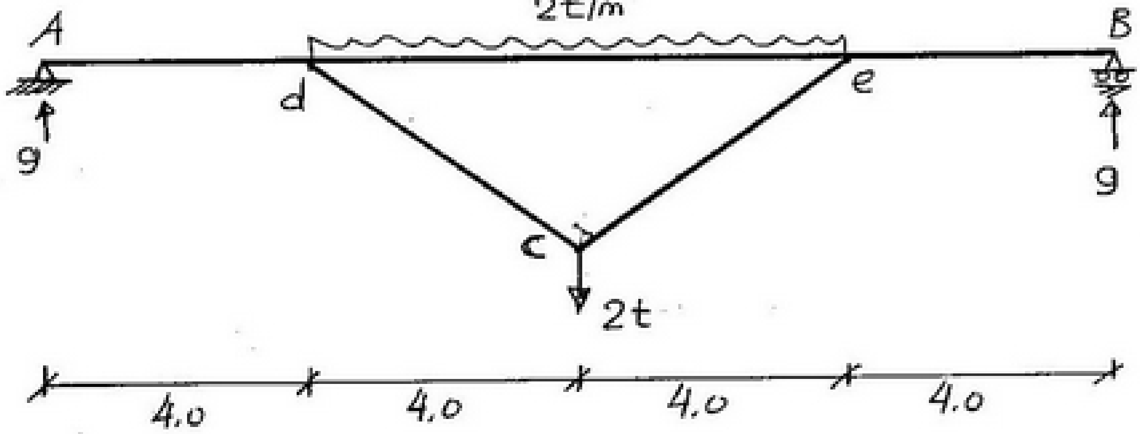
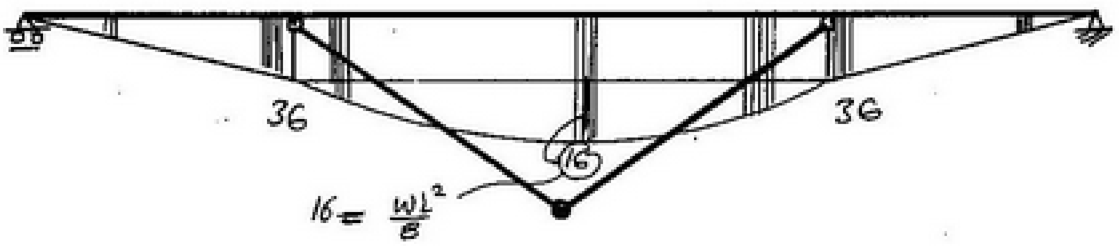
titanic_ship1912@yahoo.com

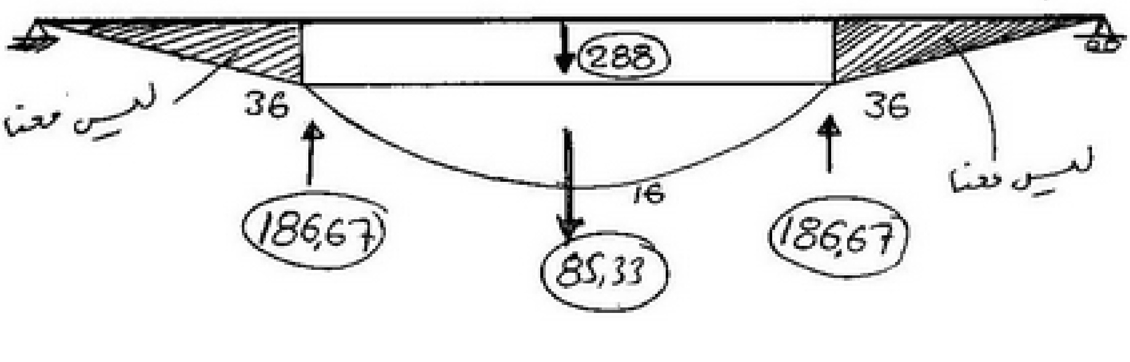
Draw B.M.D for the shown structure



- المجهول هنا العزوم عند (c, d, e) داخل الـ Closed loop
- المنشأ محدد استاتيكياً من الخارج
- ارسم العزم على كل ضلع داخل الـ loop وكمان بعد تحرير العزوم الغير معلومه .

B.M.D





scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Unknowns: M_c, M_d, M_e

But from symmetry $M_d = M_e$

at d

$$M_c * 5 + 2M_d(5+8) + \cancel{M_e}(8) = -6r_d$$
($M_e \to M_d$)

$$5M_c + 26M_d + 8M_d = -6 * 186.67$$

$$\therefore \quad 5M_c + 34M_d = -1120 \rightarrow (1)$$

at c

$$\cancel{M_e}(5) + 2M_c(5+5) + M_d(5) = -6r_c$$
($M_e \to M_d$)

$$\therefore \quad 20M_c + 10M_d = 0.0 \rightarrow (2)$$

Solve (1), (2)

$$M_c = +17.78$$

$$M_d = -35.56$$

$$\& \quad M_d = -35.56$$

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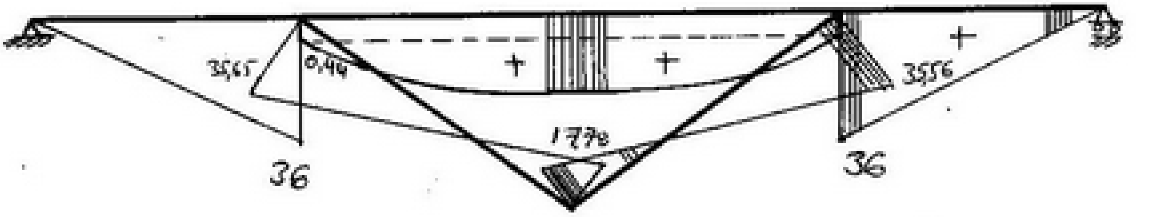
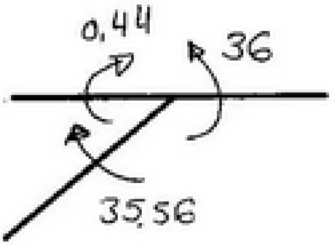
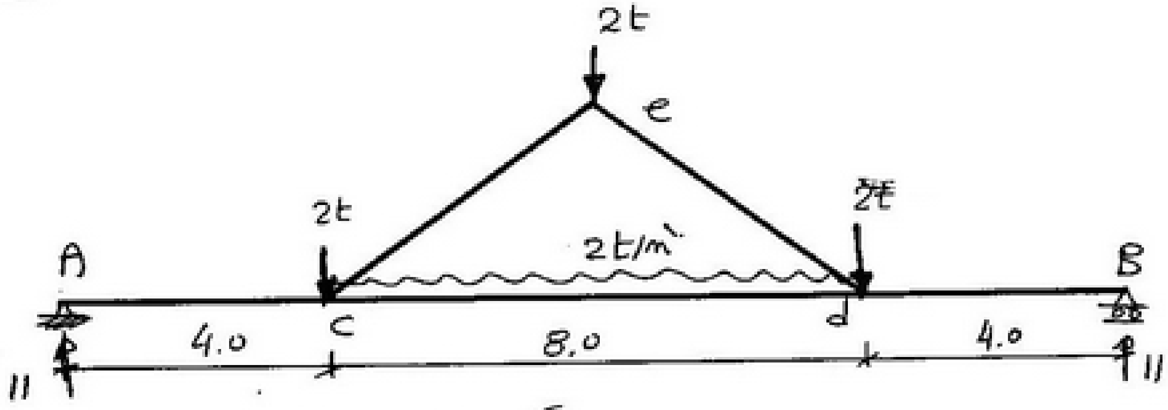


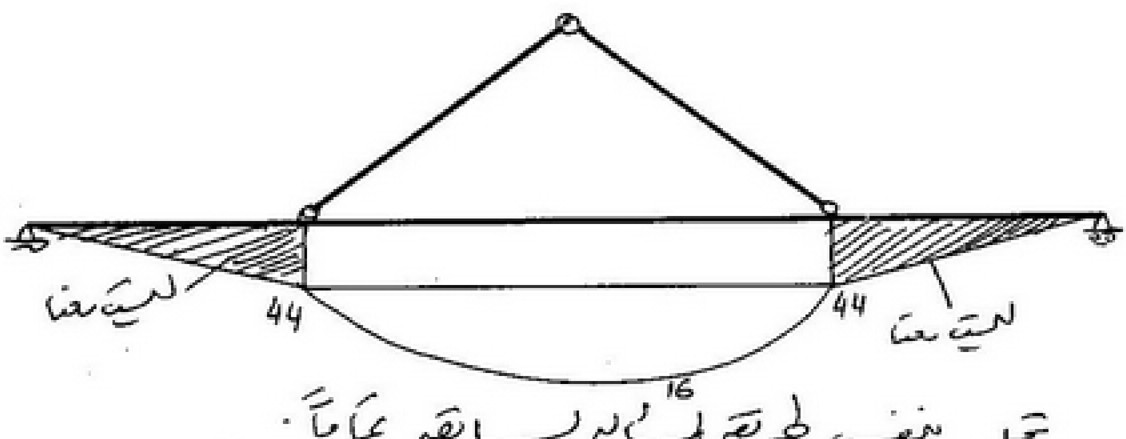
B.M.D



Ex ②



Unknowns $(M_c = M_d)$ & M_e



تحل بنفس طريقة المسألة السابقة تماما.

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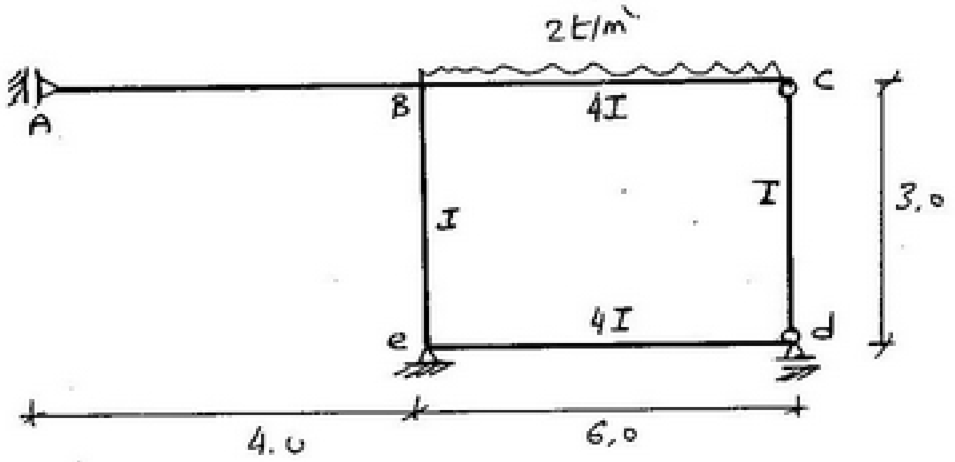
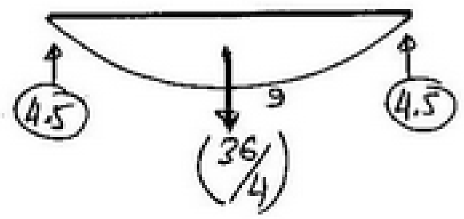
Ex final 2008



Sol^{n} Unknowns M_e, M_B



at (e)

$$M_d\left(\frac{6}{4}\right) + 2M_e\left(\frac{6}{4} + 3\right) + M_B(3) = -6\, r_e$$

($M_d \to 0.0$, $r_e \to 0.0$)

$$9M_e + 3M_B = 0.0 \longrightarrow (1)$$

at (B)

$$M_e(3) + 2M_B\left(3 + \frac{6}{4}\right) + M_C\left(\frac{6}{4}\right) = -6\, r_B$$

($M_C \to 0.0$)

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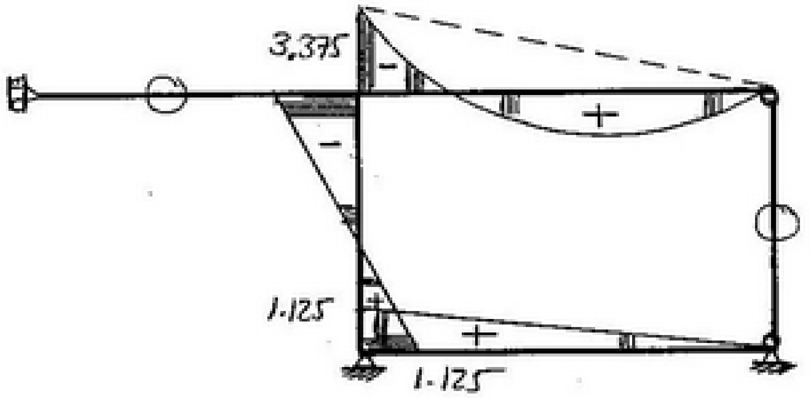
$$\therefore\ 3M_e + 9M_B = -6(4.5) = -27 \rightarrow ②$$

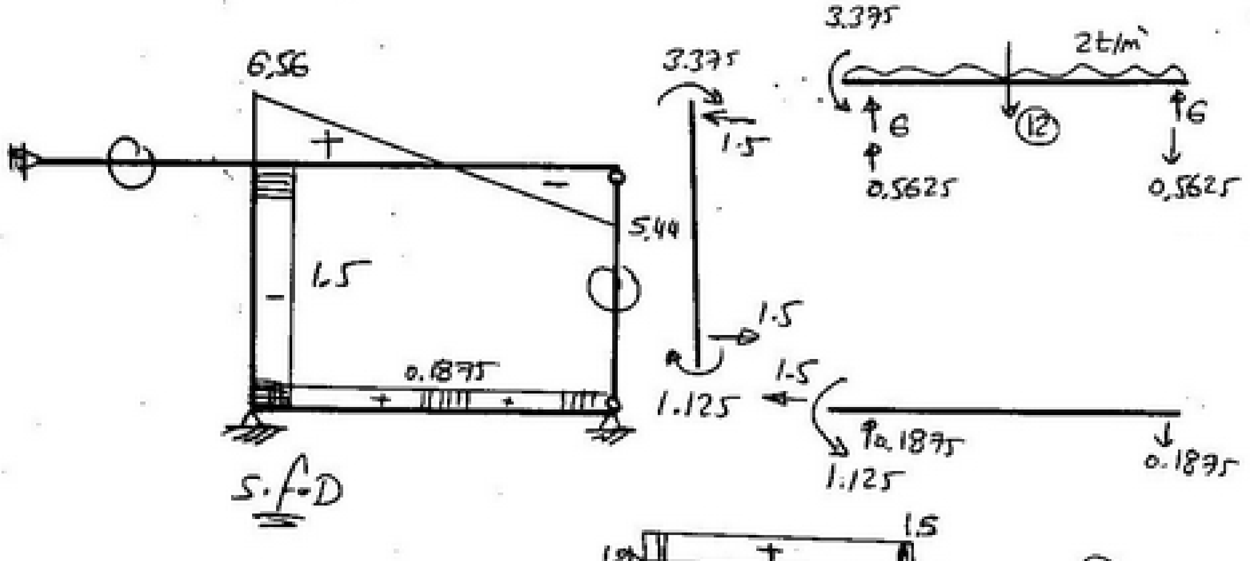
Solve ①, ② →

$$M_e = 1.125$$

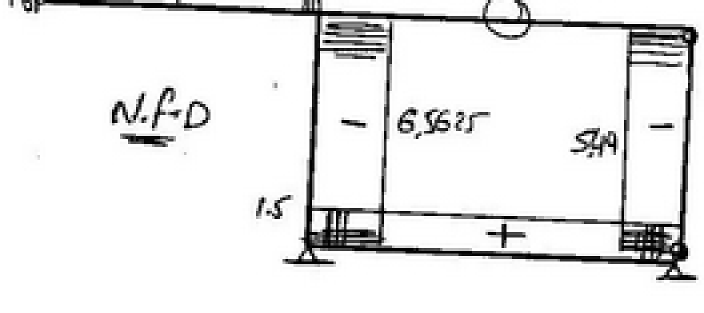
$$M_B = -3.375$$



B.M.D



S.F.D



N.F.D

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"5"

١,١٥

STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: BUCKLING الانبعاج

⑤

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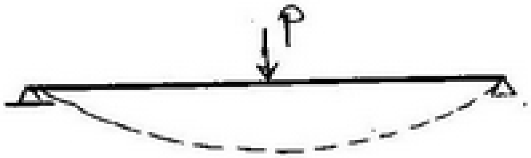
بسم الله الرحمن الرحيم

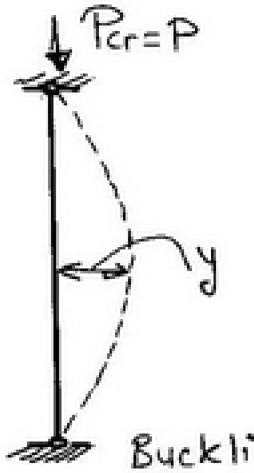
الانبعاج Buckling

ظاهرة تحدث للعناصر المحملة بأحمال محورية (axial loads)



Deflection

الحمل عمودي على المنشأ (العنصر)



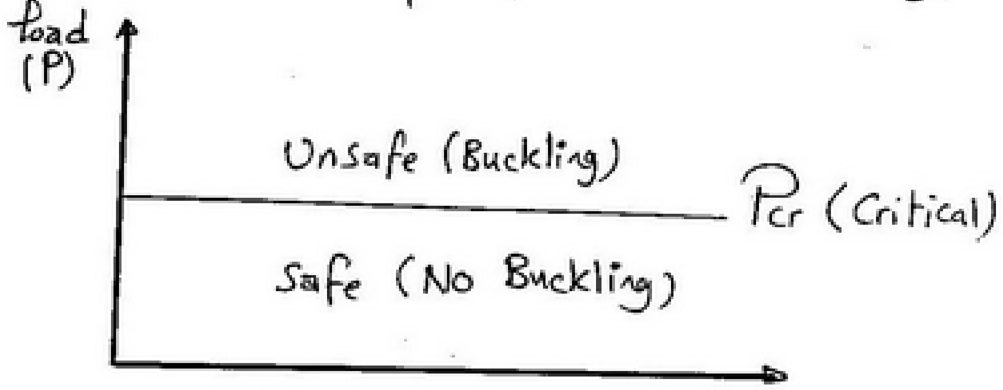
Buckling

الحمل في الاتجاه المحوري للعنصر

$$P_{cr} = \frac{\pi^2 (EI_{min})}{(L_b)^2}$$

يحدث الانبعاج عندما تكون $P_{cr} = P$

حيث أن P_{cr} = الحمل الحرج الذي عنده يحدث انبعاج للعمود



π = النسبة التقريبية = $22/7 = 3.14$

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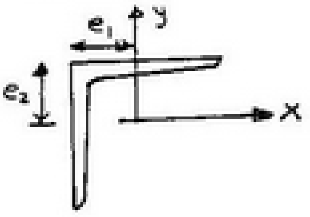
E = معامل المرونة Young's Modulus

I_{min} = أقل عزم قصور ذاتي (Peast Moment of Inertia)

إذا كان القطاع غير متماثل أي له Ixy مثل الـ Angels شرق.

$I_x = ✓$, $I_y = ✓$

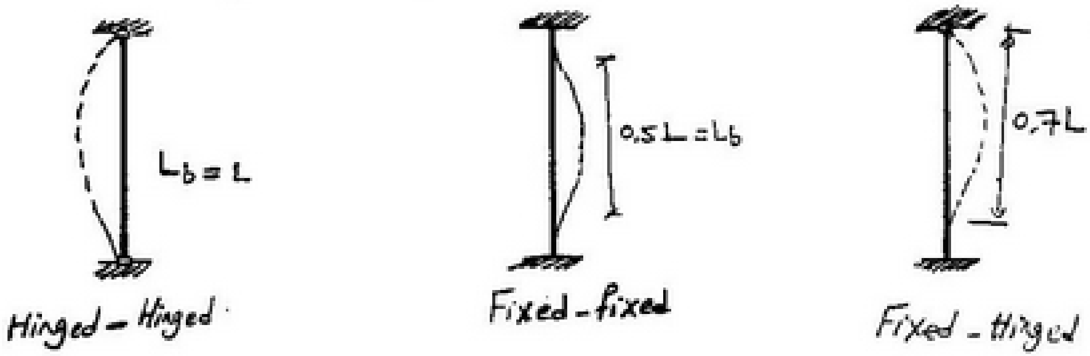
$I_{xy} = A * e_1 * e_2$

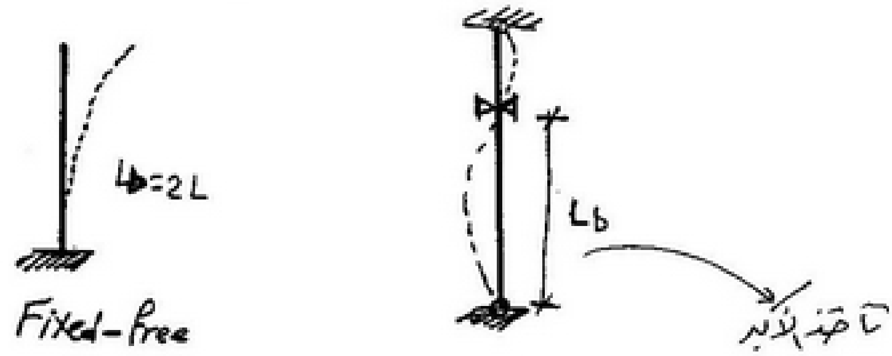


$$\therefore\ I_{min} = \left(\frac{I_x + I_y}{2}\right) - \sqrt{\left(\frac{I_x - I_y}{2}\right)^2 + I^2_{xy}}$$

L_b = طول الانبعاج ← Buckling Pength

ويعتمد اعتماداً كلياً على نظام التثبيت End Condition





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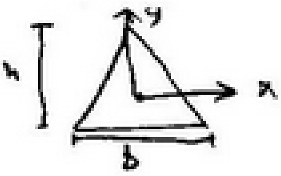
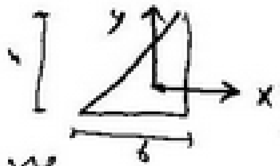
$I_x = \frac{bh^3}{36}$

$I_y = \frac{hb^3}{48}$



$I_x = \frac{bh^3}{36}$

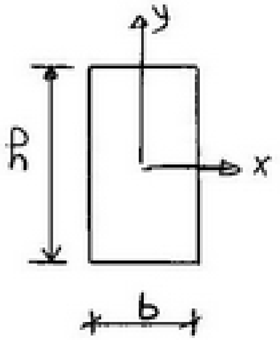
$I_y = \frac{hb^3}{36}$



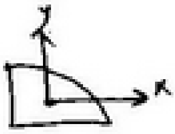
ملحوظات هامة .

$$I_x = \frac{bh^3}{12}$$

$$I_y = \frac{hb^3}{12}$$

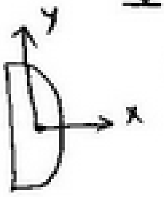


$I_x = I_y = 0.055\, r^4$

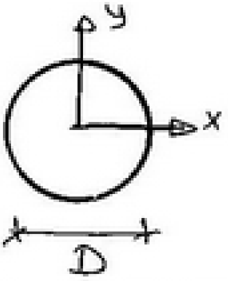


$I_x = \frac{\pi}{8} r^4$

$I_y = 0.11\, r^4$

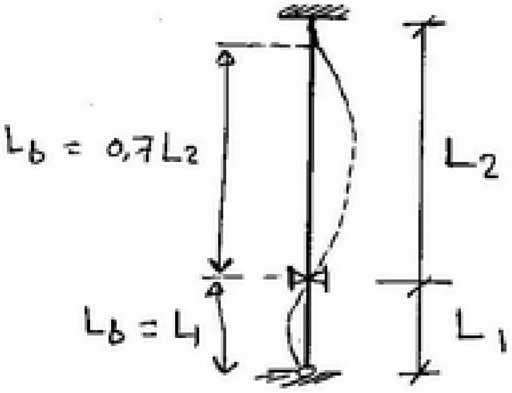


$$I_x = I_y = \frac{\pi D^4}{64}$$



تأخذ (L_b) الكبرى

$\therefore L_b = 0.7 L_2$



يتم التعبير عن الحديد دائماً

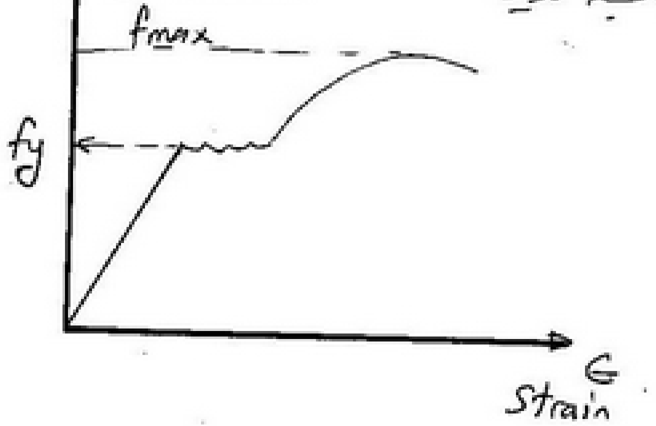
f_y / f_{max}

$24/35 = st(37)$

$2400\ kg/cm^2 = f_y$

$3500\ kg/cm^2 = f_{max}$

بالنسبة للحديد



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Slenderness Ratio (λ) (Lambda) معامل النحافة

$$\lambda = \left(\frac{L_b}{i}\right)$$

L_b = طول الانبعاج

i = radious of gyration (نصف قطر التدويم)

$$i_x = \sqrt{\frac{I_x}{A}} \quad , \quad i_y = \sqrt{\frac{I_y}{A}}$$

Permissible Buckling stresses الاجهادات المسموح بها من الانبعاج

σ_{pb} = Permissible buckling stress

تم استخدام نظرية Euler لحساب (σ_{pb})

(1) على حسب نوع الـ (steel) الحديد المكون لمادة العمود

Steel 37

$\sigma_{pc} = 1.1 \ t/cm^2$ المسموح به من الضغط

$\sigma_{pt} = 1.2 \ t/cm^2$ المسموح به من الشد

$$\lambda = \left(\frac{L_b}{i}\right)$$

$$\lambda \geq 104 \Rightarrow \sigma_{pb} = \frac{6000}{\lambda^2}$$

$$\lambda < 104 \Rightarrow \sigma_{pb} = 1.1 - 0{,}00005\,\lambda^2$$

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Steel 44 $\sigma_{pc} = 1.3 \ t/cm^2$

$$\lambda \geq 96 \Rightarrow \sigma_{pb} = \frac{6000}{\lambda^2}$$

$$\lambda < 96 \Rightarrow \sigma_{pb} = 1,3 - 0,00007\,\lambda^2$$

Steel 52 $\sigma_{pc} = 1.4 \ t/cm^2$

$$\lambda \geq 85 \Rightarrow \sigma_{pb} = \frac{7500}{\lambda^2}$$

$$\lambda < 85 \Rightarrow \sigma_{pb} = 1,4 - 0,000065\,\lambda^2$$

Critical load & critical stresses P_{cr} & σ_{cr}

$$P_{cr} = \frac{\pi^2 * EI_{min}}{(L_b)^2}$$

$$\sigma_{cr} = \frac{P_{cr}}{Area}$$

allowable = permessible = safe = P_{pb} =

$$P_{pb} = \sigma_{pb} * Area$$

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Factor of Safety (n) معامل الأمان

$$n = \frac{\sigma_{cr}}{\sigma_{Pb}} = \frac{P_{cr}}{P_{Pb}}$$

P_{Pb} = الحمل المسموح به من الإنبعاج = $(\sigma_{Pb} * A)$

Coeff of Buckling (k) معامل الإنبعاج

$$k = \frac{\sigma_{Pc}}{\sigma_{Pb}}$$

← Max Fiber stresses

أ) العمود عليه حمل محوري فقط (P)

$$\sigma = \frac{P}{A} * k \ngtr \sigma_{Pc}$$

ب) العمود عليه (P) حمل محوري

M_x عزم حول محور (X)

M_y عزم حول محور (Y)

يتم حساب الإجهادات من المعادلة التالية

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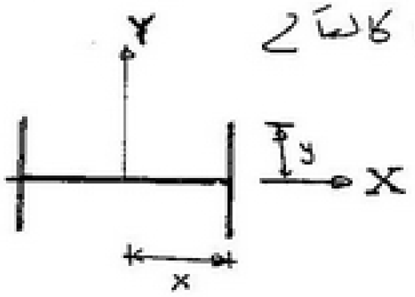
$$\sigma = \frac{P}{A} k \pm \frac{M_x}{I_x} \cdot y + \frac{M_y}{I_y} \cdot x$$

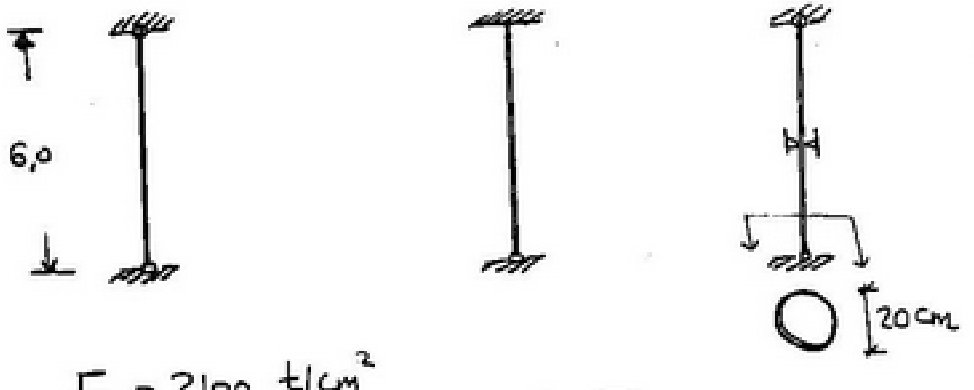
حيث (x ، y) تم ايجادها كالآتي



Ex Calc

1. Critical stresses
2. Factor of safety
3. Max Fiber stresses.

for the shown cases



$E = 2100 \ t/cm^2$

$P = 100 t$

st 37

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Sol:

Properties of section

$$A = \frac{\pi}{4}(20)^2 = 314.16\ cm^2$$

$$I_x = I_y = \frac{\pi}{64}(D)^4 = \frac{\pi}{64}(20)^4 = 7854\ cm^4$$

$$i_x = i_y = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{7854}{314.16}} = 5$$

Requirements

① Hinged - Hinged

$L_b = L = 6m = 600\ cm$

$$P_{cr} = \frac{\pi^2 * E I_{min}}{(L_b)^2}$$

$$= \frac{\pi^2 * 2100 * 7854}{(600)^2} = 452.17\ t$$

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{452.17}{314.16} = 1.44\ t/cm^2$$

(*) -

$$\lambda = \frac{L_b}{i} = \frac{600}{5} = 120$$

$\therefore \lambda = 120 > 104 \Rightarrow$

$$\sigma_{pb} = \frac{6000}{\lambda^2} = \frac{6000}{(120)^2}$$

$$= 0.4167\ t/cm^2$$

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$$n = \frac{\sigma_{cr}}{\sigma_{pb}} = \frac{1.44}{0.4167} = \underline{\underline{3.456}}$$

$$\sigma_{max} = \frac{P}{A} * K$$

$$K = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0.4167} = 2,64$$

$$\therefore \quad \sigma_{max} = \frac{100}{314.16} * 2,64 = 0,84 \ t/cm^2 < 1.1$$

(ok)

② (Fixed – hinged)

$$L_b = 0.7L = 0.7 * 6 = 4.20 \ m$$

$$P_{cr} = \frac{\pi^2 * EI_{min}}{(L_b)^2} = \frac{\pi^2 * 2100 * 7854}{(420)^2}$$

$$= \underline{922,81} \ t$$

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{922,81}{314.16} = 2,94 \ t/cm^2$$

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$$\lambda = \frac{L_b}{i} = \frac{420}{5} = 84$$

$$\lambda = 84 < 104$$

$$\therefore \sigma_{Pb} = 1.1 - 0,00005\,\lambda^2$$

$$= 1.1 - 0,00005 * 84^2 = 0,747 \ t/cm^2$$

إستمرار

$$n = F.S = \frac{\sigma_{cr}}{\sigma_{Pb}} = \frac{2.94}{0.747}$$

$$= \boxed{3.93}$$

$$K = \frac{\sigma_{pc}}{\sigma_{Pb}} = \frac{1.1}{0.747} = 1,47$$

Max Fiber stresses

$$\sigma = \frac{P}{A} * K = \frac{100}{314.16} * 1.47 = 0,4687 \ t/cm^2$$

Case III Laterally supported

$$L_b = L/2 = 600/2 = 300 \ cm$$

ونشتغل عادي جداً

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$P_{cr} = 1808.7\ t$

$\sigma_{cr} = 5.75$

$\lambda = 60 = 300/5$

$\sigma_{pb} = 1.1 - 0.00005\lambda^2 = 0.92$

$n = \frac{\sigma_{cr}}{\sigma_{pb}} = 6.25$, $k = \frac{\sigma_{pc}}{\sigma_{pb}} = 1.1956$

$\sigma = \frac{P}{A} k = \frac{100}{314.16} * 1.1956 = 0.38\ t/cm^2$

ملاحظ

σ زيادة ← (L_b) زيادة

P_{cr} نقصان

σ_{pb} نقصان

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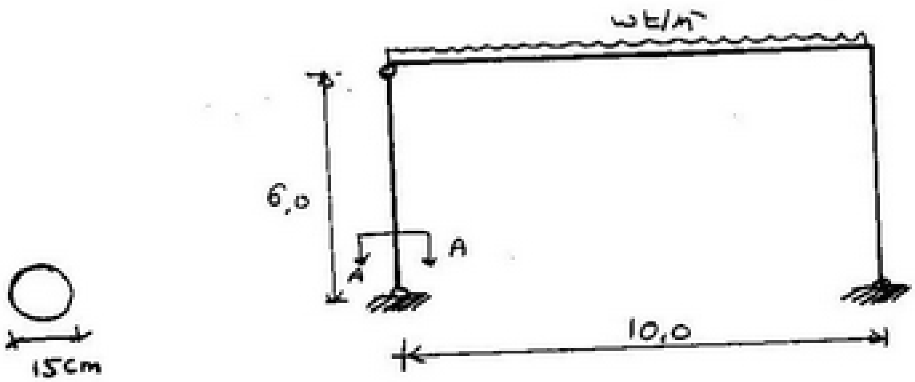

Req (w)

such that, st (37), $\sigma_{pc} = 1.1$, $\sigma_{pt} = 1.2$

sol^o

properties of section

$$A = \frac{\pi}{4}(15)^2 = 176.71 \; cm^2$$

$$I_x = I_y = \frac{\pi}{64}(15)^4 = 2845 \; cm^4$$

$$i_x = i_y = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{2845}{176.71}}$$

$$= 3.75$$

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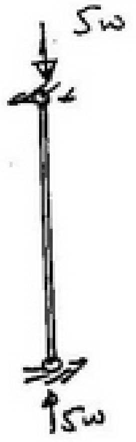

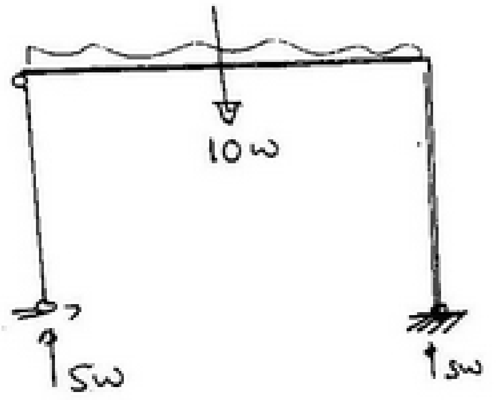

$L_b = 6m = 600\ cm$

$$\lambda = \frac{L_b}{i^o} = \frac{600}{3.75} = 160$$

$$160 = \lambda > 104$$

$$\sigma_{pb} = \frac{6000}{\lambda^2} = \frac{6000}{(160)^2} = 0{,}2344 \ t/cm^2$$

$$K = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0{,}2344} = 4.7$$

$$\sigma = \frac{P}{A} * K = \frac{5w}{176{,}71} * 4.7 \ngtr \sigma_{pc}$$

$$1.1 = \frac{5w}{176.71} * 4.7 \Rightarrow w = 8.27\ t/m'$$

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STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: BUCKLING الانبعاج

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بسم الله الرحمن الرحيم

For the shown truss req the value of (P)

Given each angle

$I_x = I_y = 235\ cm^4$

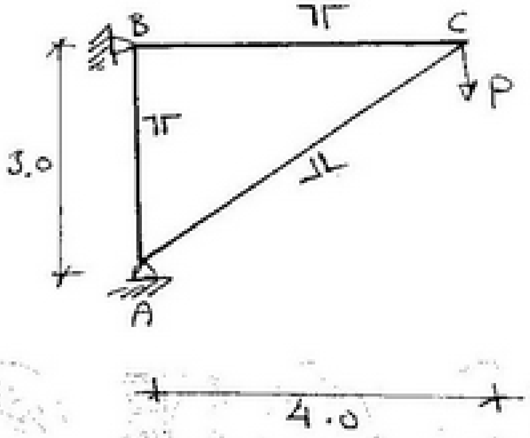
$A = 26.2\ cm^2$

$e = 2.98$

$E = 2000\ t/cm^2$

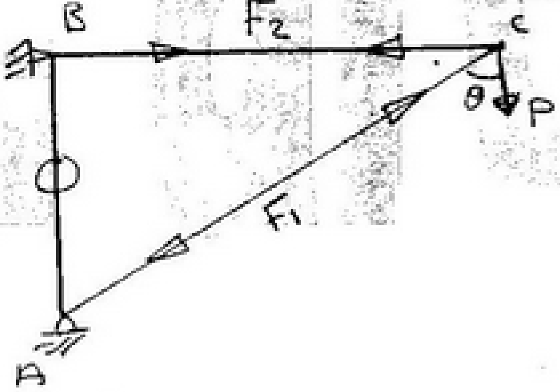
$\sigma_{pc} = 1.1\ t/cm^2$

$\sigma_{pt} = 1.2\ t/cm^2$



أولاً

أوجد القوى في الأعضاء



Joint (c)

$\Sigma f_y = 0.0$

$F_1 \cos\theta = P \Rightarrow F_1 = \frac{P}{\cos\theta} = 1.67\,P$ Comp

$\Sigma f_x = 0.0 \Rightarrow$

$F_1 \sin\theta = F_2 \Rightarrow F_2 = 1.33\,P$ tension

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العضو (AB) يصل بين (two hingeس) ⟵ AB عليه قوه

(AB = Zero force Member) Zero مقدارها

العضو (BC) القوه عليه ⟵ شد Tension

لا علاقة له بال buckling

$$\sigma = \frac{Force}{Area} = \frac{1.33P}{A}$$

$$A = 2 * 26.2 = 52.4\ cm^2$$

two angle

$$\sigma = \frac{1.33P}{52.4} = 1.2$$

$$P = 47.28\ t$$

Member (AC) القوه عليه = (1.67P) ضغط

$$\sigma_c = \frac{Force}{Area} * k$$

$$\frac{1.67P}{52.4} = \frac{Force}{Area}$$

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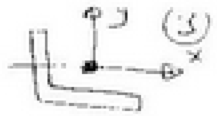
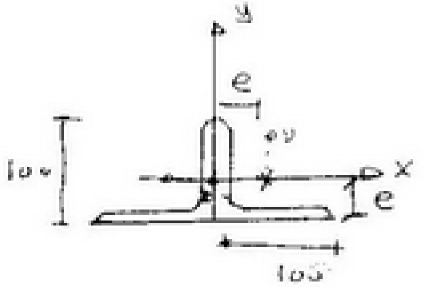


$L_b = 5.0 \, m = 500 \, cm$



$I_x = I_{xi} + A_i x t_i^2$

$= 2 \, (I_x \text{ one angle})$

$= 2 * 235 = 470 \, cm^4$

$I_y = I_{yi} + A_i * \delta_i^2$

$= 2 \left(235 + 26.2 * 2.98^2\right) = 935.33 \, cm^4$

$i_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{470}{52.4}} = 2.995$

$i_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{935.33}{52.4}} = 4.22$

$\lambda_x = \frac{L_{bx}}{i_x} = \frac{500}{2.995} = 166.94$

$\lambda_y = \frac{L_{by}}{i_y} = \frac{500}{4.22} = 118.48$

نختار λ الأكبر

$\lambda = 166.94 > 104$

$F_{pb} = \frac{6000}{\lambda^2} = \frac{6000}{(166.94)^2} = 0.215 \, t/cm^2$

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titanic_ship1912@yahoo.com

$$K = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0.215} = 5.11$$

$$\sigma_c = \frac{\text{Force}}{A} * K$$

$$= \frac{1.67\,P}{52.4} * 5.11 = \boxed{1.1} \;(\sigma_{pc})$$

$$P = 6.\underline{75}\ t$$

مما سبق يتضح ان لدينا قوتين ← 47.28 طن ← شد
← ٦,٧٥ طن ← ضغط

∴ القوة المؤثرة على المنشأ لابد ان تكون اقل القيم

$$\text{Force } P = \underline{\underline{6.75}}\ t$$

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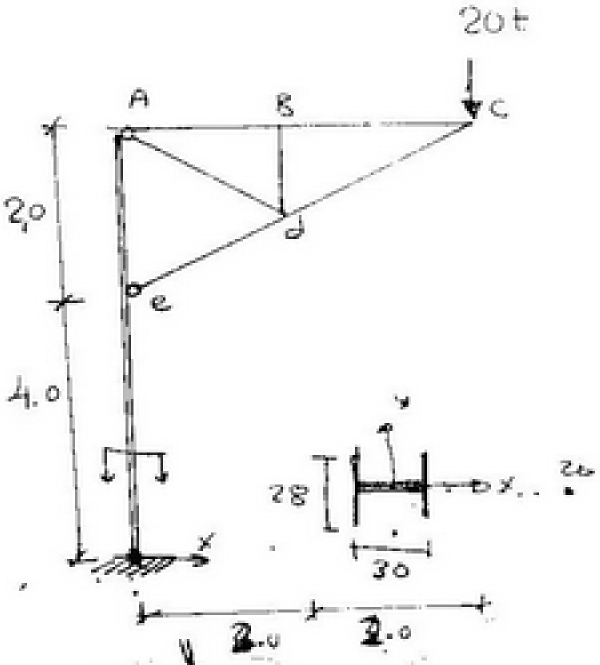
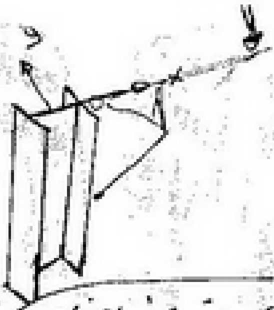
Check the Safety of each member if the Cross section of truss Members is circular 10 Cm diameter and the Col. section is I-Beam No (30) St (37)



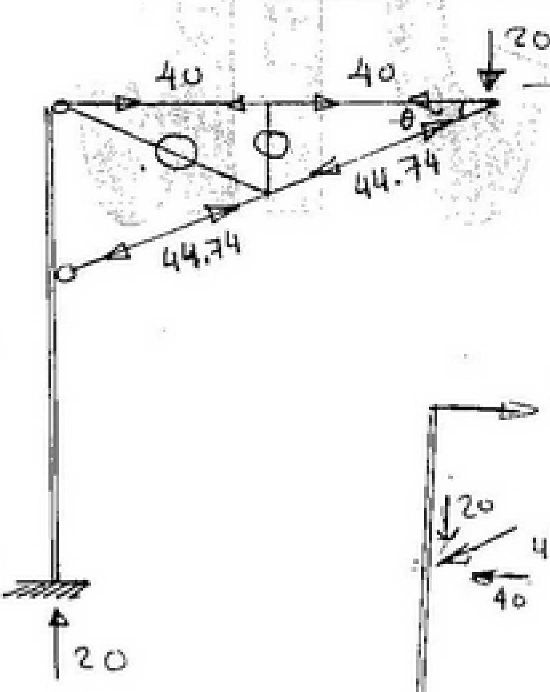
$I_x = 7400\ cm^4$

$I_y = 17000\ cm^4$

$A = 172\ cm^2$



أولاً أوجد القوى في الأعضاء

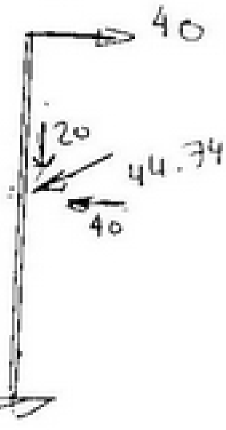


$\sin\theta = 0.447$

$\cos\theta = 0.894$

B.M.D

N.F.D



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Truss Members

Member AB = Member BC

Force = (40 t) tensim

$\sigma = \frac{Force}{Area} \rightarrow$

Area $= \frac{\pi}{4}(10)^2 = 78.53 \; cm^2$

$\sigma = \frac{40}{78.53} = 0.51 \; t/cm^2 < \sigma_{pt}$

ok

$= 0.51 < 1.2 \; t/cm^2$

ok Safe

Member Bd, Member Ad

Safe → Zero force Member.

Member dc = Member de

force = 44.74 Comp

$\sigma = \frac{Force}{A} \times k$

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$$L_b = \sqrt{5} = 2,236 \text{ m} = 223,6 \text{ cm}$$

$$A = 78.53$$

$$I_x = I_y = \frac{\pi D^4}{64} = \frac{\pi (10)^4}{64} = 490,87 \text{ cm}^4$$

$$i_x = i_y = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{490,87}{78,53}} = 2.5$$

$$\lambda = \frac{L_b}{i} = \frac{223,6}{2.5} = 89.44$$

$$\lambda = 89.44 < 104$$

$$\sigma_{pb} = 1.1 - 0.00005 \lambda^2$$

$$= 1.1 - 0.00005 (89.44)^2$$

$$= 0.7 \text{ t/cm}^2$$

$$\therefore K = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0.7} = 1.57$$

$$\sigma = \frac{44.74}{78.53} * 1.57 = 0.895 \text{ t/cm}^2 < 1.1$$

ok safe

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for col^n

(Fixed - free)

$$L_b = 2L$$

$$L_b = 2 * 4.0 = 8.0\,m = 800\,cm$$

$$I_x = 7400\ cm^4$$

$$I_y = 17000\ cm^4$$

$$i_x = \sqrt{\frac{7400}{172}} = 6.56$$

$$\lambda = \frac{L_b}{i} = \frac{800}{6.56} = 121.95$$

$$\lambda > 104$$

$$\sigma_{pb} = \frac{6000}{\lambda^2} = \frac{6000}{(121.95)^2} = 0.403\ t/cm^2$$

$$K = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0.403} = 2.726$$

$$\sigma = \frac{P}{A} * K + \frac{M_x}{I_x} \cdot y + \frac{M_y}{I_y} \cdot x$$

so $M_x = Zero$

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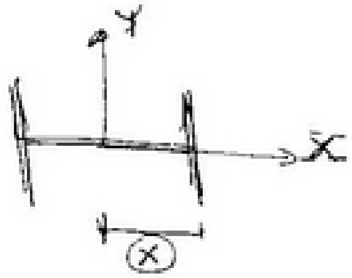
$My = 80 \ t.m$

$P = 20 \ t$

$x = 15 \ cm$



$$\sigma = \frac{20}{172} * 2.726 + \frac{80 * 10^2}{17000} * 15$$

$$= 7.37 \ t/cm^2 >>> 1.1$$

Un Safe

Sol:

1. Increase the Cross Section
2. decrease the moment

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STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: BUCKLING الانبعاج

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سؤال مهم

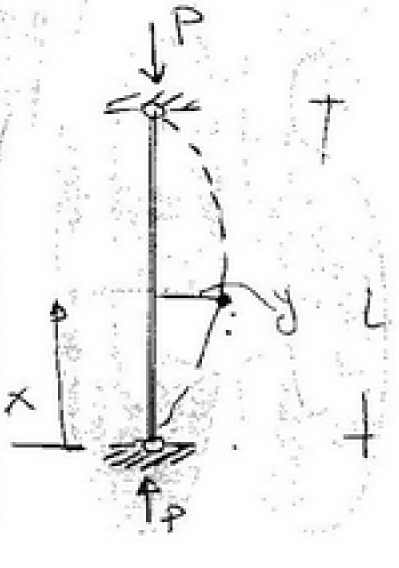
Drive an expression for (P_{cr}) in the following

Case
1. hinged – hinged.
2. Fixed – fixed
3. Fixed – hinged.
4. Fixed – free

① Hinged – Hinged

let $P = P_{cr}$

at (x)



$$M = P * y$$

$$EJy'' = EJ\frac{d^2y}{dx^2} = -M$$

$$EJy'' = -P * y$$

$$\therefore EJy'' + P * y = 0.0$$

$$y'' + \frac{P}{EJ}y = 0.0$$

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Let $\frac{P}{EI} = c^2$

$$\therefore \quad y'' + c^2 y = 0.0$$

حل هذه المعادلة التفاضلية.

$$y = A \cos cx + B \sin cx$$

حيث (B ، A) ثوابت.

B.Cs at $x = 0 \Rightarrow y = 0$

$$0 = A \cos(0) + B \sin(0)$$

$$A = 0.0$$

$$\therefore \quad y = B \sin cx$$

at $x = L \Rightarrow y = 0.0$

$$0 = B \sin cL$$

لا يمكن أن تساوي B صفراً

$$\therefore \quad \sin cL = 0.0$$

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$\therefore \quad cL = \pi, 2\pi, 3\pi = n\pi$

$n = 1, 2, 3$

$$cL = \pi$$

$$\sqrt{\frac{P}{EJ}} \times L = \pi$$

$$P = \frac{\pi^2 \times EJ}{L^2}$$

hinged _ hinged $\Rightarrow L = L_b$

$$P = \frac{\pi^2 EJ}{(L_b)^2}$$

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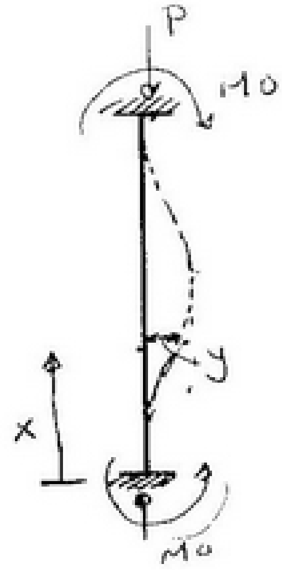
Fixed – Fixed

Let

P = Critical load

y = def at x

M_o = Fixed End moment



at (x)

$$M = P.y - M_o$$

$$EI * \frac{d^2y}{dx^2} = -M$$

$$EIy'' = M_o - P.y$$

$$\therefore \frac{d^2y}{dx^2} + \frac{P}{EI} y = \frac{M_o}{EI} \Rightarrow C^2 = P/EI$$

$$y'' + C^2 * y = \frac{1}{EI} (M_o)$$

$$y = \underbrace{A \cos Cx + B \sin Cx}_{\text{Homogeneous Sol}^{\text{n}}} + \text{Particular Integration}$$

$$\text{Particular Int} = \frac{1}{D^2 + C^2} * [\ = \text{الجزء بعد علامة}\ ]$$

= بالتفاضل الثاني لما بعد علامة = D^2

D^2 = zero

$$P.I = \frac{1}{C^2} * \frac{M_o}{EI} = \left(\frac{M_o}{P}\right)$$

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$$\therefore \; y = A\cos cx + B\sin cx + \frac{M_o}{P}$$

B.Cs

at $x = 0. \Rightarrow \frac{dy}{dx} = 0.0.$

$$\frac{dy}{dx} = -A*C \sin cx + BC\cos cx$$

$$\therefore \; 0 = BC$$

$$\therefore \; B = 0.0$$

at $x = 0 \Rightarrow y = 0.0 \Rightarrow 0 = A + \frac{M_o}{P}$

$$\therefore \; A = -\frac{M_o}{P}$$

$$\therefore \; y = \frac{-M_o}{P}\cos cx + \frac{M_o}{P}$$

$$= \frac{M_o}{P}\left(1 - \cos cx\right)$$

at $(x = L) \Rightarrow y = 0.0$

$$0 = \frac{M_o}{P}\left(1 - \cos cL\right)$$

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$\therefore \cos(cL) = 1$

$\therefore cL = \cancel{0}, 2\pi, 4\pi, \ldots$

the least value (significant) $= 2\pi$

$\therefore cL = 2\pi$

$\sqrt{\frac{P}{EI}} * L = 2\pi$

$\therefore P = \frac{4\pi^2 * EI}{L^2}$, $L_b = 0.5L$

$$P_{cr} = \frac{\pi^2 * EI}{(L_b)^2}$$ #

$L_b = 0.5L$ (fixed - fixed)

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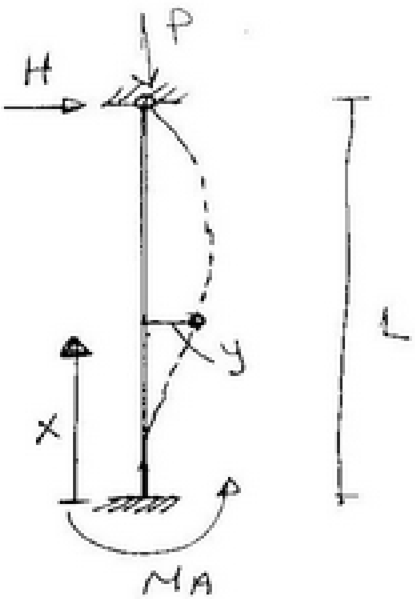
(Hinged – Fixed)

M_A = The Moment at the fixed End.

H = H^{ℓ} reaction at hinge



at (x)

$$M = P.y - H(L - x)$$

$$EI \frac{d^2y}{dx^2} = -M = H(L-x) - P.y$$

$$EI\, y'' = H(L - x) - P.y \rightarrow c^2 = P/EI$$

$$y'' + c^2 * y = \frac{H(L-x)}{EI}$$

$$\therefore y = A \cos cx + B \sin cx + P.I$$

$$P.I = \frac{1}{D^2 + c^2}\left[\frac{H * (L - x)}{EI}\right)$$

D^2 = zero

$$\therefore P.I = \frac{H(L-x)}{P}$$

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$$\therefore \quad y = A\cos Cx + B\sin Cx + \frac{H(L-x)}{P}$$

B.Cs

at $x = 0 \Rightarrow y = 0.0$

$$A = -\frac{HL}{P}$$

$$\frac{dy}{dx} = -AC\sin Cx + BC\cos Cx - \frac{H}{P}$$

at $x = 0 \Rightarrow \frac{dy}{dx} = 0.0$

$$0 = CB - \frac{H}{P}$$

$$B = \frac{H}{PC} = \frac{H}{P * C} = \frac{H}{P} * \frac{1}{C}$$

at $x = L \Rightarrow y = 0.0$

$$0.0 = -\frac{HL}{P}\cos CL + \frac{H}{P} * \frac{1}{C}\sin CL$$

$$\frac{H}{P} * \frac{1}{C}\sin CL = \frac{HL}{P}\cos CL$$

$$\therefore \quad \tan(CL) = CL$$

يعني نرجع إن tan الزاوية = الزاوية وهذه الزاوية تكون صغيرة جداً جداً

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حيث زمع بالتقدير الدائرى radians وهذه زاوية تقريباً

(4.5 radian)

$\therefore$ $CL = 4.5$

$$L^2 * P/EI = 20.25$$

$$P = \frac{2\pi^2 * EI}{L^2}$$

$$P_{cr} = \frac{\pi^2 * EI}{(L_b)^2}$$

$$L_b = 0.7L$$

$$(L_b)^2 = 0.49 L^2$$

$$\approx 0.5 L^2$$

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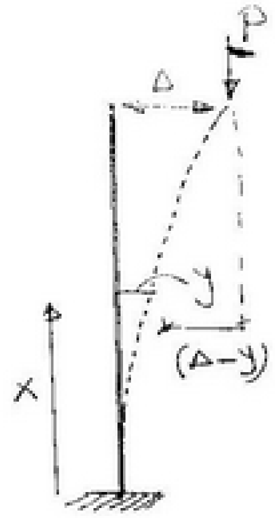
Fixed _ free

$M = -P(\Delta - y)$

$M = -P.\Delta + Py$



$EI * \frac{d^2y}{dx^2} = (P.\Delta - Py)$

$\frac{d^2y}{dx^2} = \frac{+P}{EI}\Delta - \frac{P}{EI}y$

$c^2 = P/EI$

$y'' + c^2 * y = c^2\Delta$

$\therefore\ y = A\cos cx + B\sin cx + P.I$

$P.I = \frac{1}{D^2+c^2}(c^2\Delta)$, $D^2 = 0.0$

$P.I = \Delta$

$\therefore\ y = A\cos cx + B\sin cx + \Delta$

$\frac{dy}{dx} = -Ac\sin cx + Bc\cos cx$

B.Cs at $x = 0.0 \Rightarrow \frac{dy}{dx} = 0.0$

CR

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$\therefore \quad B = 0.$

at $x = 0 \Rightarrow y = 0 \Rightarrow A = -\Delta$

$$\therefore \quad y = -\Delta \cos(cx) + \Delta$$

$$y = \Delta \left[1 - \cos cx \right]$$

at $x = L \Rightarrow y = \Delta$

$$\Delta = \Delta \left(1 - \cos cL \right)$$

$$\therefore \quad \cos cL = 0.0$$

$$cL = \frac{\pi}{2} = \frac{3\pi}{2} = \frac{5\pi}{2}$$

$$\therefore \quad cL = \pi/2$$

$$P = \frac{\pi^2 * EI}{4L^2} = \frac{\pi^2 * EI}{(L_b)^2}$$

$L_b = 2L \Rightarrow$ (fixed - free)

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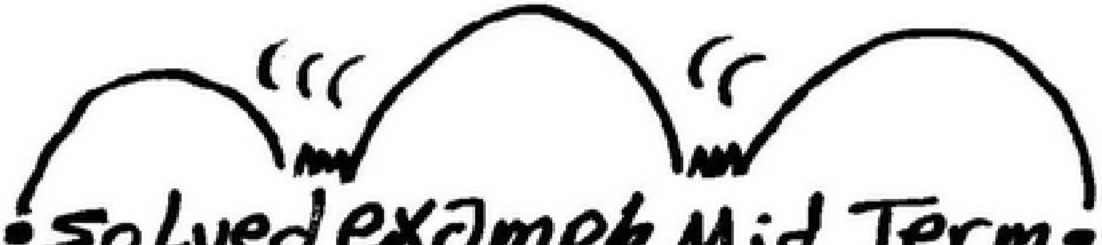
8

STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: BUCKLING الانبعاج



Solved example Mid Term

2007

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titanic_ship1912@yahoo.com

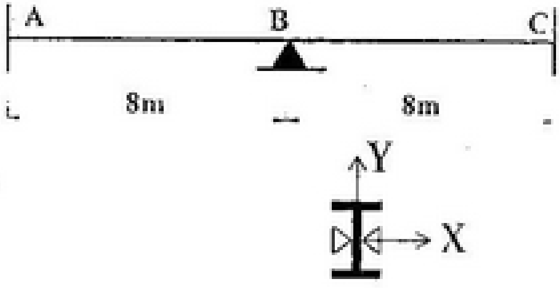
Course Name : Structural Analysis (2)		Mid Term Exam	
Course Code :		Date	: 27-3-2007
Level : Second Year Civil		Time	: 1 Hour
Department : Structural Engineering	Zagazig University	No. of pages	: 1
Term No. : 2	Faculty of Engineering	No. of Questions	: 3

Solve As You Can

Problem No. (1)

For the shown fixed strut, if the beam is restricted in plane and out of plane at (B) as shown, a rise in temperature occur Δt.

Find the max. value of Δt which make the strut still stable.



Cross Section is (SIB NO. 32)

Steel 52 $\alpha = 1.2\times10^{-5}$

$E = 2100\ t/cm^2$, $A = 77.8\ cm^2$,

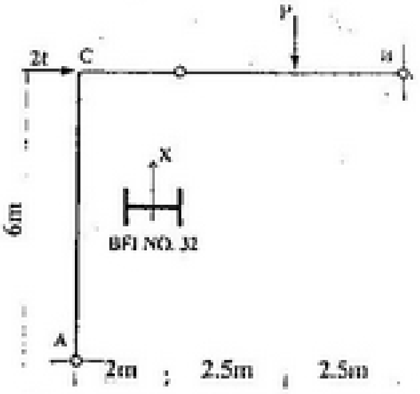
$I_x = 12510\ cm^4$ & $I_y = 782 cm^4$

Problem No. (2)

In the shown determinate structure; if the column (AC) is restricted at out of plane at (C) (Steel 44), Determine:

a) The maximum permissible load P.

b) The critical load for the same column.



Section of column is BFI NO. 32

$E = 2000\ t/cm^2$, $A = 190\ cm^2$,

$I_x = 45000\ cm^4$ & $I_y = 10800\ cm^4$

$\lambda = \frac{l_k}{i} \geq 96$ $\sigma_{pk} = \frac{6000}{(\lambda)^2}$

$\lambda < 96$ $\sigma_{pk} = 1.3 - 0.00007(\lambda)^2$

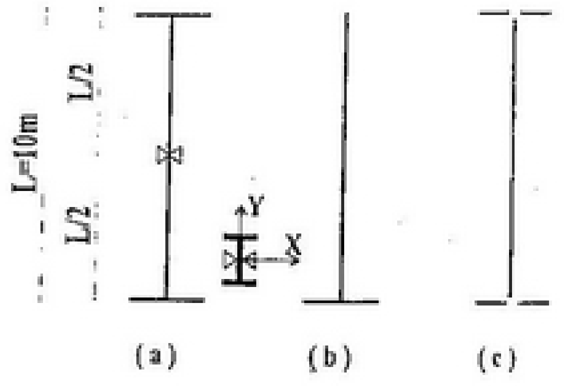
Problem No. (3)

For the shown columns, Calculate for each case

a) The critical load.

b) The save load.

c) Factor of safety against buckling.



Section of column is BFI NO. 16

Steel 37 L= 10 m

$E = 2000\ t/cm^2$ & $A = 111\ cm^2$,

$I_x = 11690\ cm^4$ & $I_y = 4150\ cm^4$

$\lambda = \frac{l_k}{i} \geq 104$ $\sigma_{pk} = \frac{6000}{(\lambda)^2}$

$\lambda < 104$ $\sigma_{pk} = 1.1 - 0.00005(\lambda)^2$

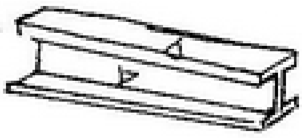
Prof. Dr. Sayed Abd-El Salam Assist.Prof. Osman Shallan

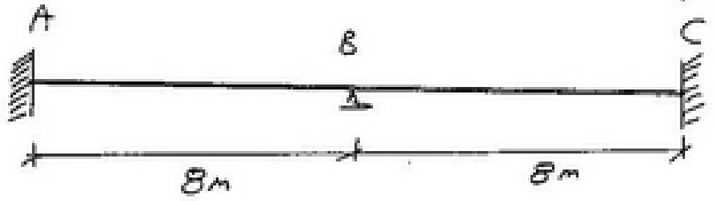
Dr.Hanaa El- Sayed

scanner by : mahmoud ashraf

titanic_ship1912@yahoo.com

بسم الله الرحمن الرحيم





Steel 52

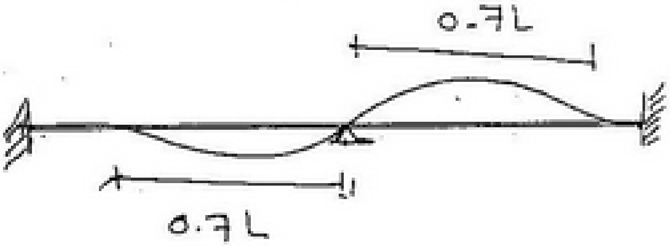
$\alpha = 1.2 * 10^{-5}$

$E = 2100\ t/cm^2$, $A = 77.8\ cm^2$

$I_x = 12510$, $I_y = 782\ cm^4$

rey (Δt)

(Fixed-Hinged)



$L_b = 0.7 * 800 = \underline{560}\ cm$

$$P_{cr} = \frac{\pi^2 E I_{min}}{(L_b)^2}$$

$$= \frac{\pi^2 * 2100 * 782}{(560)^2} = \underline{51.68\ t}$$

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** due to temprature

$$\sigma = E * \epsilon$$

$$\epsilon = \frac{\Delta L}{L} \quad , \quad \Delta L = \alpha . \Delta t . L$$

$$\therefore E * \epsilon = E \alpha . \frac{\Delta t . L}{L}$$

$$\sigma = E . \alpha . \Delta t$$

$$= 2100 * 1.2 * 10^{-5} * \Delta t$$

$$= \underline{0.0252 \Delta t}$$

$$\underline{Load} = \sigma * A$$

$$= 0.0252 (t) * 77.8 = \underline{1.96 \Delta t}$$

$$\therefore 1.96 \Delta t \not> P_{cr}$$

$$\Delta t \leqslant \frac{P_{cr}}{1.96}$$

$$\Delta t = \frac{51.68}{1.96} \leqslant \underline{\underline{26.36^{\circ}}}$$

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③ نجيب I_{max} I_{min} في حالة ما إذا كان القطاع غير منتظم وله (I_{xy})

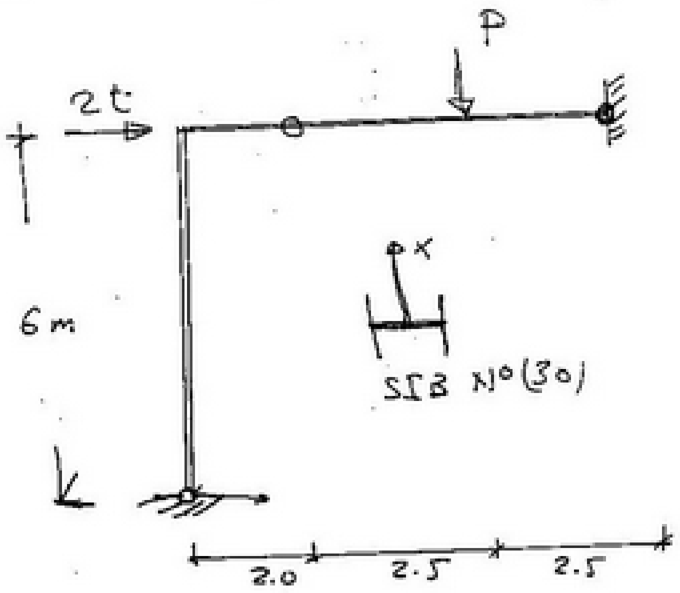
$$I_{max,min} = \left(\frac{I_x + I_y}{2}\right) \pm \sqrt{\left(\frac{I_x - I_y}{2}\right)^2 + I_{xy}^2}$$

$A = 190$

$E = 2000$

$I_x = 45000$,

$I_y = 10800$



Sol

L_b = (hinged - hinged)

= **600** cm

$$i_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{45000}{190}} = 15.39$$

$$i_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{10800}{190}} = \underline{7.54}$$

$$\lambda_x = \frac{L_b}{i_x} \quad , \quad \lambda_y = \frac{L_b}{i_y}$$

نجيب $\underline{\lambda}$ أكبر

$$\lambda_y = \frac{600}{7.54} = \underline{79.58} < \underline{96}$$

$$\sigma_{pb} = 1.3 - 0.00007\,\lambda^2$$

$$= 1.3 - 0.00007\,(79.58)^2$$

$$\sigma_{pb} = \underline{0.8567}\ t/cm^2$$

$$k = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.3}{0.8567} = \underline{1.517}$$

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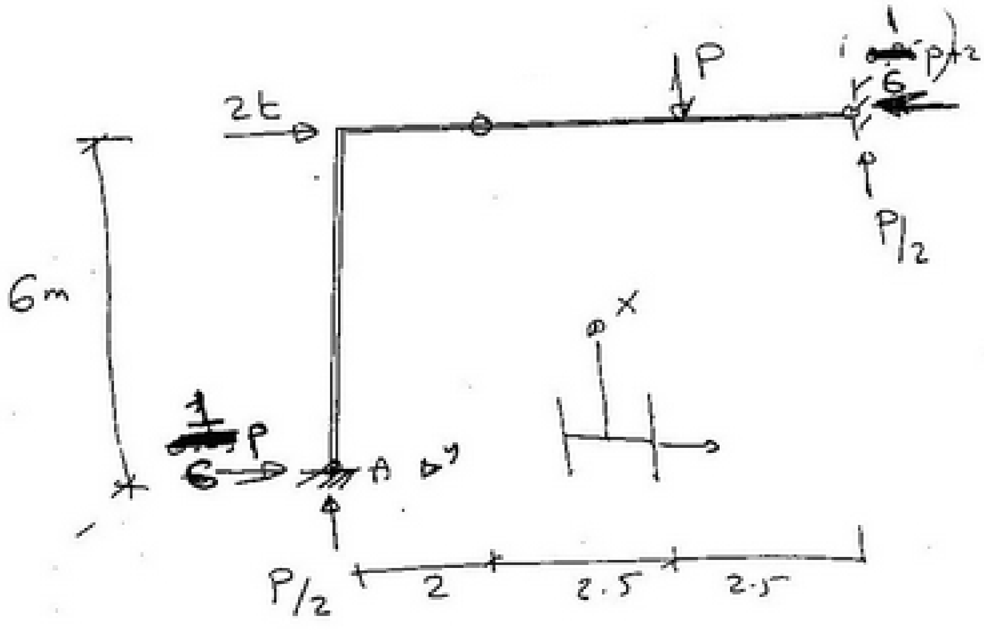
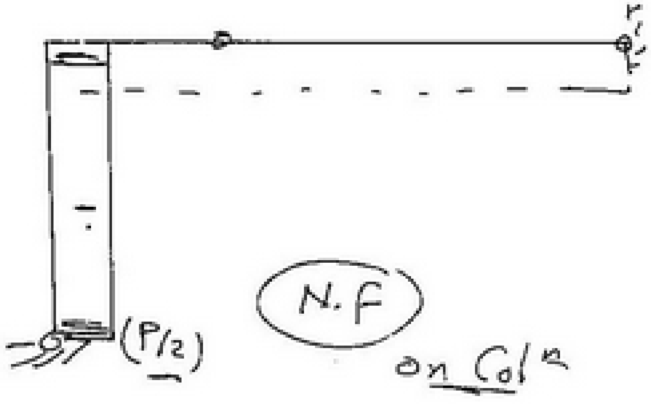


$\Sigma M_A = 0$

$2 * 6 + P * 4.5 - P/2 * 7 - X_B * 6 = 0$

$X_B = \frac{12 + 1.0P}{6} = 2 +$ [redacted] $\frac{1}{6} P$

$\Sigma F_x = 0 \rightarrow X_A =$ [redacted] $\frac{1}{6} P = P/6$



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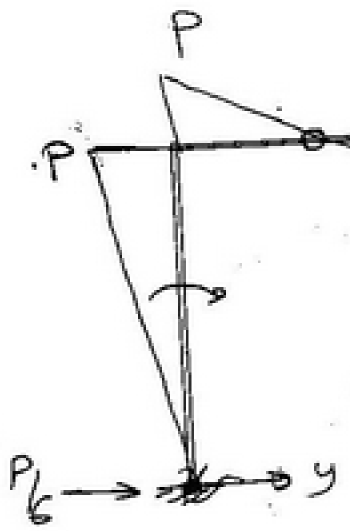

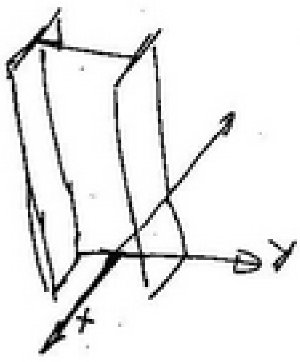

أصبح العمود عليه

$P/2 = \underline{N}$

$\underline{P} = \underline{M_x}$

$$\sigma = \frac{N}{A} * (k) + \frac{M_x}{I_x} \cdot y$$

t.cm

$$1.3 = \frac{P/2}{190} * 1.517 + \frac{P * 10^2}{450000} * 16$$

$$\boxed{P = \underline{\underline{32,87}}\, t}$$

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$$P_{cr} = \frac{\pi^2 E I_{min}}{(L_b)^2}$$

$$= \frac{\pi^2 * 2000 * 10800}{(600)^2} = \underline{592.17} \, t$$

$$\sigma_{cr} = \frac{P_{cr}}{A} = 3.11 \, t/cm^2$$

$$F.S = \frac{\sigma_{cr}}{\sigma_{pb}} = \frac{3.11}{0.8567}$$

$$= \boxed{3.64}$$

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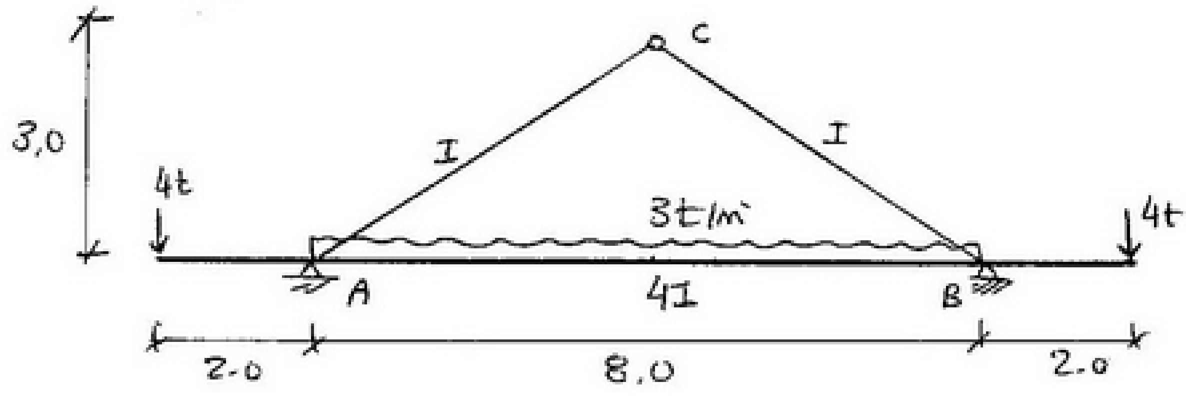
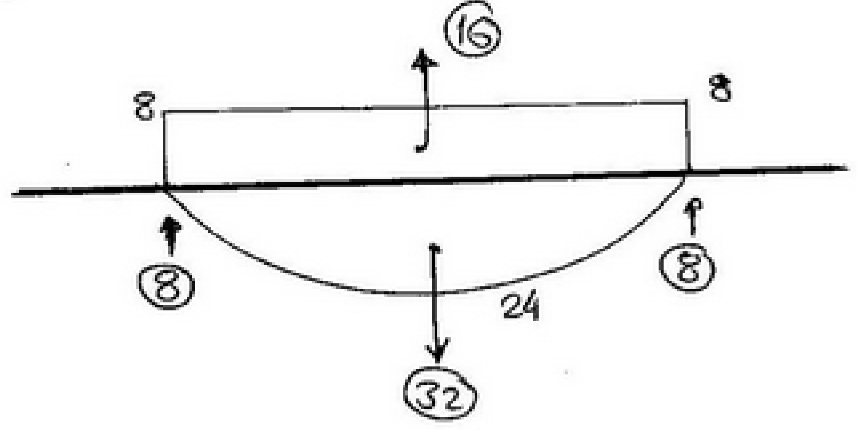
Draw B.M.D, S.f.D, N.f.D



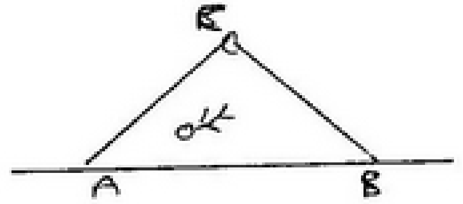
Sol: using 3M equation

Unknowns MA, MB

from symmetry MA = MB



at A (put yourself in loop)



∴ rA = −8

$$M_B * \frac{8}{4} + 2M_A\left(\frac{8}{4} + 5\right) + M_C(5) = -6(r_A)$$

(M_C → 0.0)

$$2M_C + 14M_A = -6(-8) = +48$$

(M_C → M_A)

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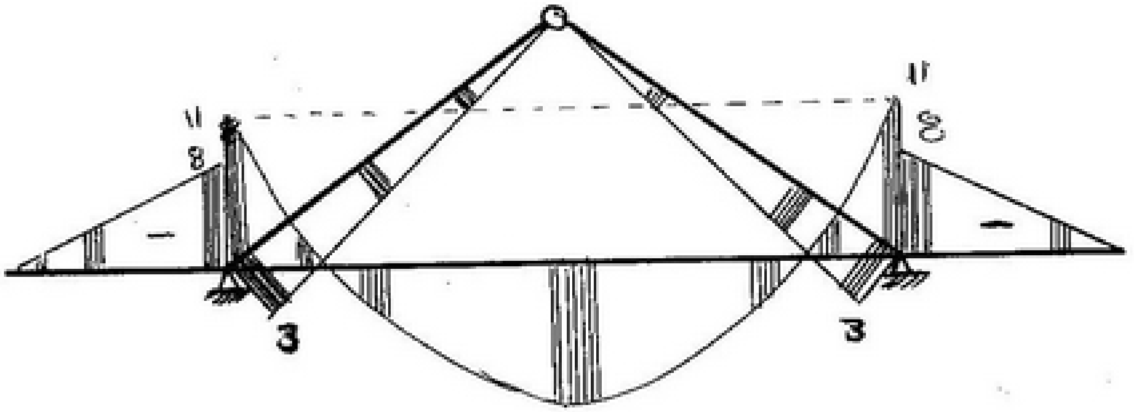
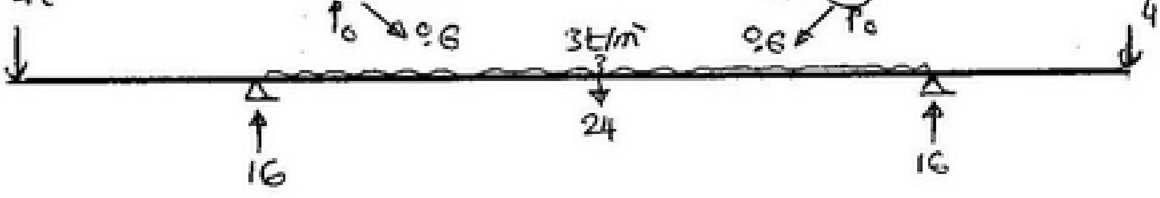
$\therefore M_A = M_C = +3$

موجب ③ معناها داخل بـ top



B.M.D



Free Body Diagram

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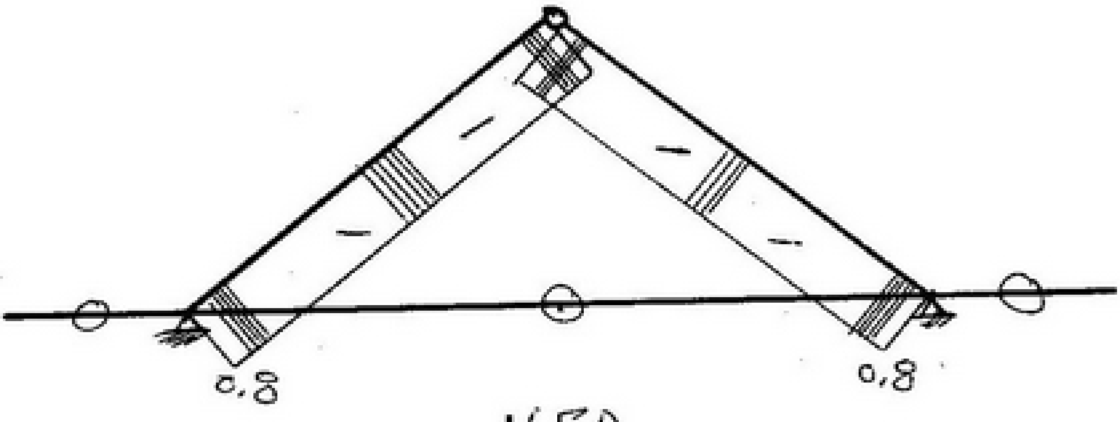
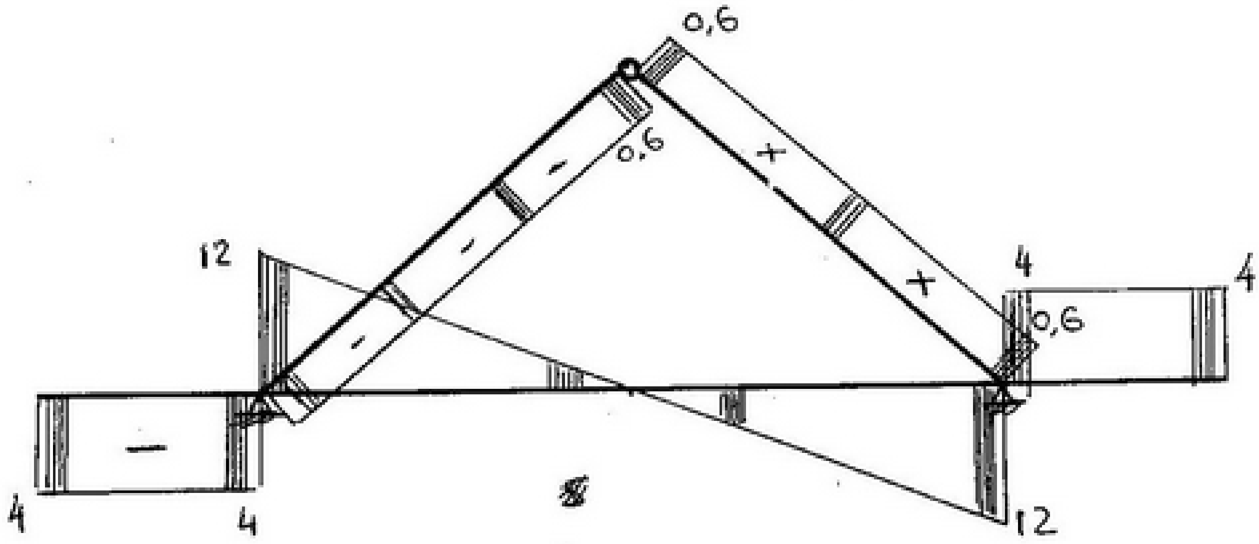


N.F.D



(S.F.D)

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STRUCTURE MECHANICS

2 nd Year

CIVIL

CH1: BUCKLING الانبعاج

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

بسم الله الرحمن الرحيم

In the Shown structure, if the Col^n AC is restricted in direction (x-x) at c Calculate

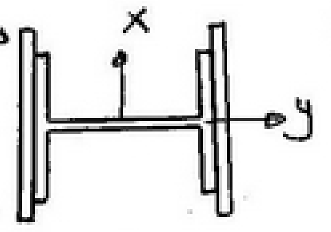
a) Max value of Uniform load w

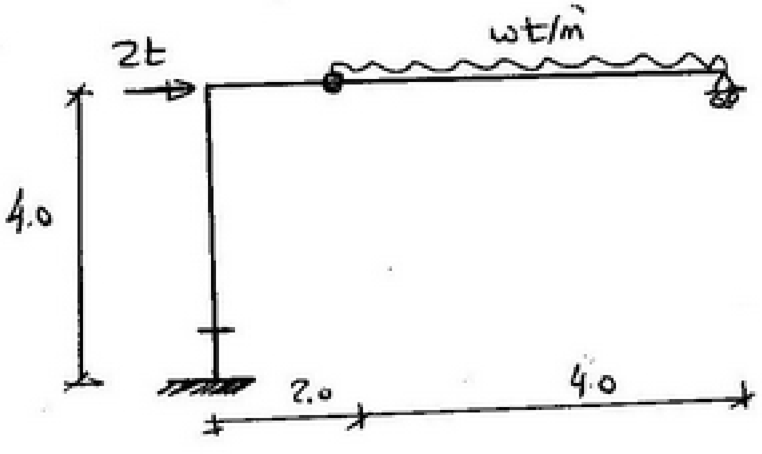
b) permissible value of load (safe) such that the Col^n is vertically (axially loaded)

if the section is BFIB NO 36

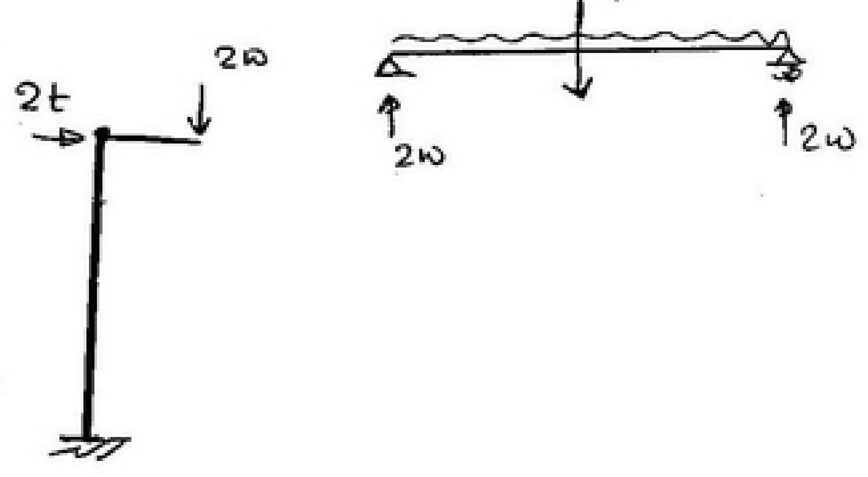
$I_x = 45000 \ cm^4$, $I_y = 10800 \ cm^4$, $A = 190 \ cm^2$

$E = 2000 \ t/cm^2$, $\sigma_{pc} = 1.4 \ t/cm^2$





Sol^n



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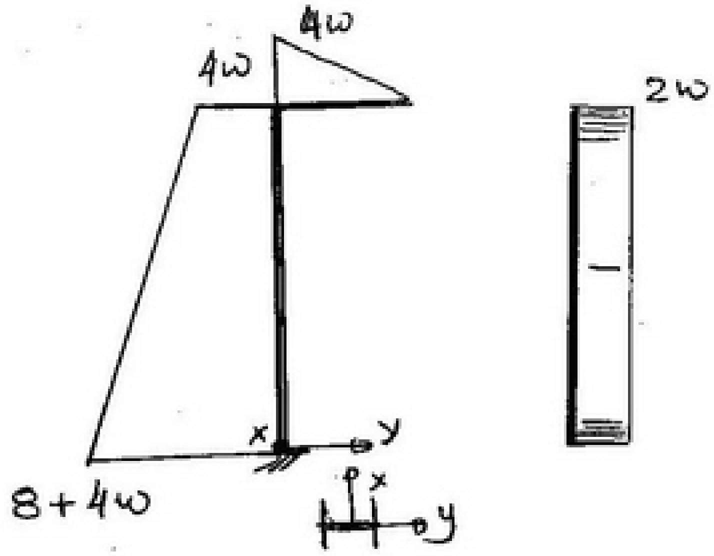
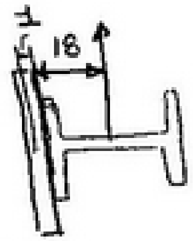


$\therefore$ $P = 2w$

$M_x = 8 + 4w$, $m_y = 0.0$



Properties of section.

$I_x = I_x(I_{beam}) + I_x(\text{plates})$

$= 45000 + 2\left(\frac{40*2^3}{12} + 40*2*19^2\right)$ ($19 = 18+1$)

$= 102813.33\ cm^4$

$I_y = I_y(I_{beam}) + 2(\text{plates})$

$= 10800 + 2\left(\frac{2*40^3}{12}\right) = 32133.33\ cm^4$

$A = A_{Ibeam} + \text{Area plates}$

$= 190 + 2*2*40 = 350\ cm^2$

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$$i_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{102813.33}{350}} = 17.14 \text{ cm}$$

$$i_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{32133.33}{350}} = 9.58 \text{ cm}$$

Buckling Length

نلاحظ أن العمود restricted عند (C) أي أنه مقيد حركته .

ثابت out of plane ولكنه حر في in plane [illegible]

(fixed - free) [illegible]

$$L_{by} = 2L \quad (\text{Fixed free})$$

$$= 2 * 4 = 8 \text{ m} = 800 \text{ cm}$$

$$L_{bx} = 0.7L \; (0.7 * 4) = 2.8 \text{ m} \; (\text{fixed - Hinged})$$

$$= 280 \text{ cm}$$

$$\lambda_x = \frac{L_{bx}}{i_x} = \frac{280}{17.14} = 16.33$$

$$\lambda_y = \frac{L_{by}}{i_y} = \frac{800}{9.58} = 83.5$$

نأخذ λ الكبرى

$$\lambda = \lambda_y = \underline{\underline{83.5}}$$

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$\lambda = 83.5 < 85$

$$\therefore \sigma_{Pb} = 1.4 - 0.000065\,\lambda^2$$

$$= 1.4 - 0.000065 * (83.5^2)$$

$$= 0.947 \text{ t/cm}^2$$

$$k = \frac{\sigma_{Pc}}{\sigma_{Pb}} = \frac{1.4}{0.947} = 1.48$$

$$\sigma_{max} = \frac{P}{A}(k) + \frac{M_x}{I_x} \cdot y$$

t.cm

$$1.4 = \frac{2w}{350}(1.48) + \frac{(8 + 4w)\,10^2}{102813.33}(20)$$

$$\therefore w = \underline{14.42} \text{ t/m}$$

Max value of $w = 14.42$ t/m

Safe value of load → $\sigma_{Pb} * Area$

$= \underline{331.45}$ tons

لعمود يتحمل لقوة رأسية فقط

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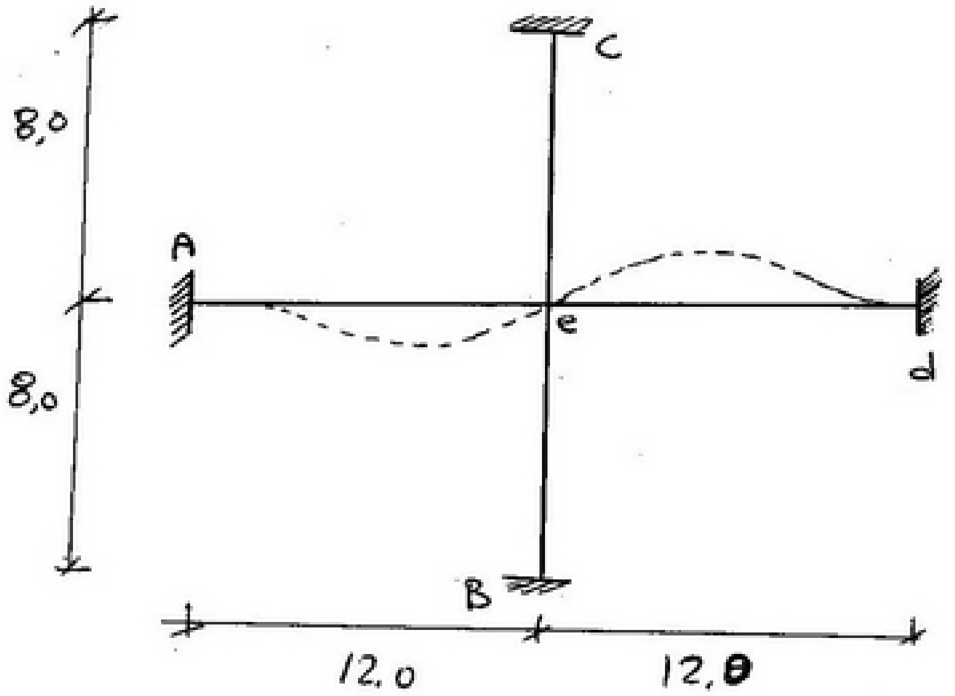
Ex(2) For the shown fixed frame a rise in temprature occur (Δt), find the max value of (Δt) which make the frame still stable. (Frame restricted at e in the out of plane direction)

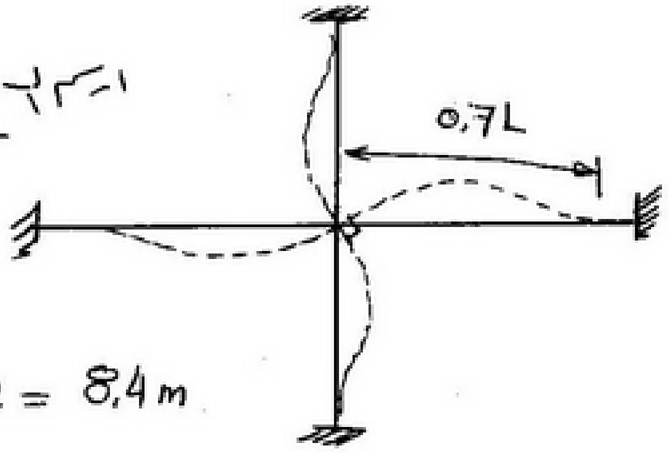
$A = 53.4$, $I_x = 5740\ cm^4$, $I_y = 288\ cm^4$

$\alpha = 1.2 \times 10^{-5}$, $E = 2100$



Sol.

Elastic Curve [illegible]



$L_b = 0.7L$

زي دا

Fixed - Hinged

$L_b = 0.7 \times 12 = 8.4\ m$

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$$P_{cr} = \frac{\pi^2 EI}{(L_b)^2}$$

$$= \frac{\pi^2 * 2100 * 288}{(840)^2} = \underline{\underline{8.46\,t}}$$

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{8.46}{53.4} = 0.158\ t/cm^2$$

stress due to temprature.

$$\sigma = E\alpha \cdot \Delta t$$

$$= 2100 * 1.2 * 10^{-5} * \Delta t$$

$$= 0.0252\ \Delta t$$

$$\therefore \quad \sigma \ngtr \sigma_{cr}$$

$$0.0252\ \Delta t \ngtr 0.158 \Rightarrow$$

$$\Delta t \ngtr \underline{\underline{6.27^\circ}}$$

$$\therefore \quad \Delta t < \underline{6.27^\circ}$$

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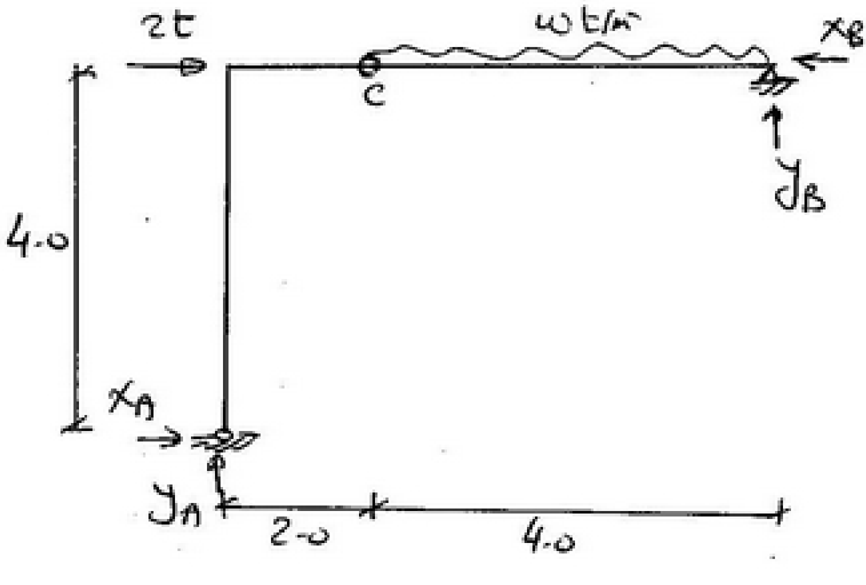
req w

شرط لم يتحرك

مع ملاحظة

أن 3 hinged frame



ΣM_C right $= 0.0$

$$\Rightarrow \quad Y_B = 2w$$

$$\Sigma F_y = 0.0 \quad \Rightarrow Y_A = 2w$$

$$\Sigma M_A = 0.0 \quad \Rightarrow \quad 2 * 4 + 4w * 4 - 2w * 6 - X_B * 4 = 0.0$$

$$\therefore \quad X_B = \frac{8 + 4w}{4} = (2 + w)$$

$$\Sigma F_x = 0.0 \quad \Rightarrow \quad X_A = w \rightarrow$$

OR ΣM_C down $= 0.0 \quad \Rightarrow$

$$Y_A * 2 = X_A * 4$$

$$2w * 2 = X_A * 4$$

$$\therefore \quad X_A = w \rightarrow$$

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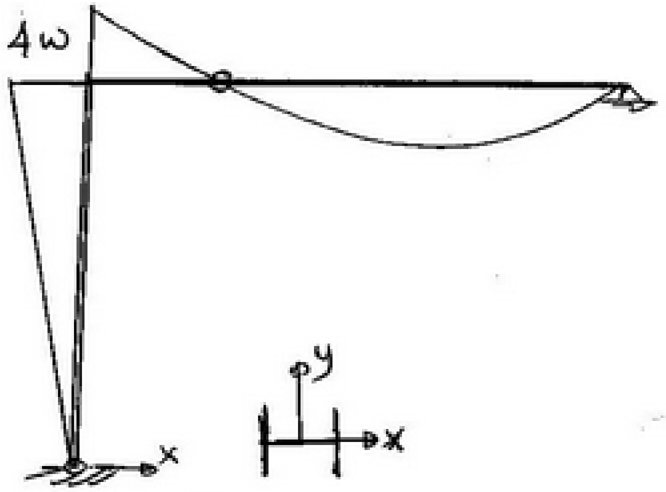
N.F



B.M.D

$\therefore \quad P = 2w \ (t)$

$M_y = 4w \ t.m$

ويتم الحل عادى كما فى المسألة الأولى

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STRUCTURE MECHANICS

2 nd Year

CIVIL

CH: INFLUENCE LINES

scanner by : mahmoud ashraf
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بسم الله الرحمن الرحيم

Influence line for staticaly Indeterminate Structures

خطوط التأثير للمنشآت الغير محددة استاتيكيا

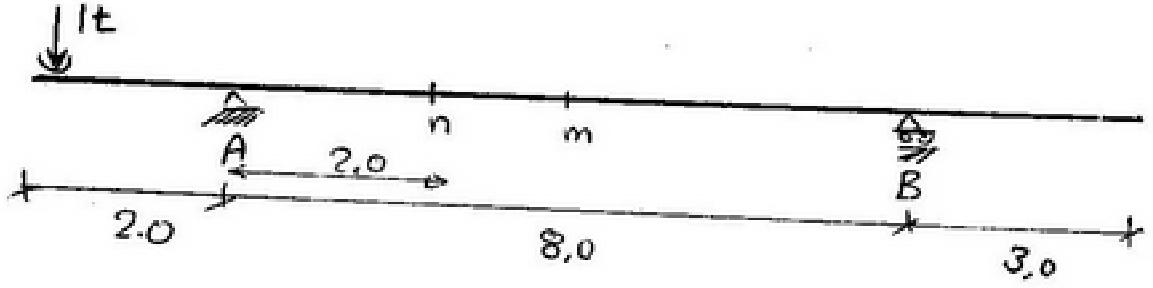
ما يعرف بـ (Influence line)

منحنيات تمثل (Straining Actions) ← B.M , S.F , N.F عند

قطاع محدد نتيجة مرور حمل مقداره 1 طن من أول المنشأ حتى آخره.

المطلوب = رسم الـ I.L = Influence line لردود الأفعال - لقص Shear والعزوم Moment للمنشآت غير المحددة استاتيكيا

Revision



Req IL $Y_A, Y_B, M_n, M_m, Q_n, Q_m, Q_{Ar}, Q_{AL}, Q_{Br}, Q_{BL}$

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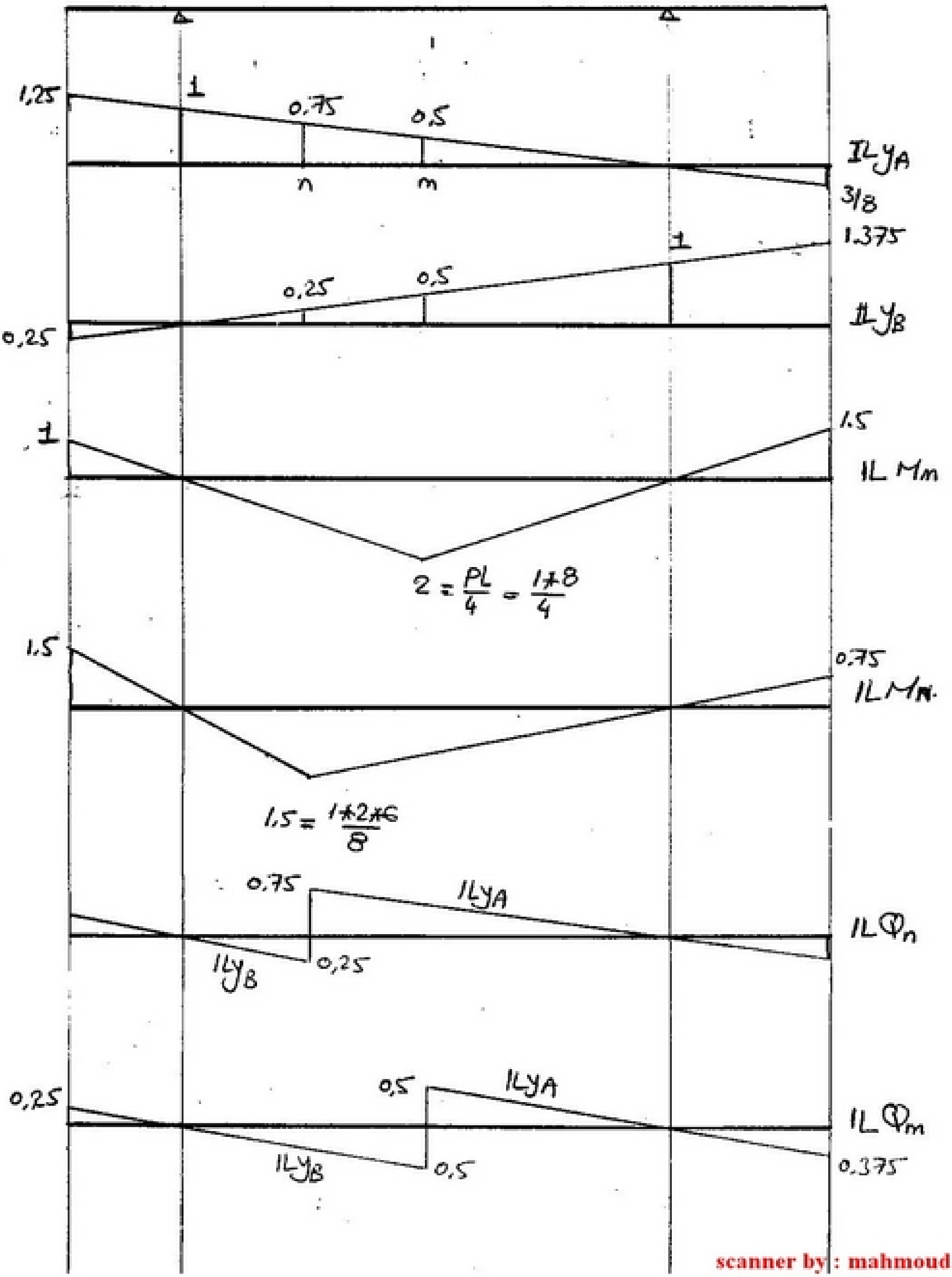
مسألة محددة استاتيكيا



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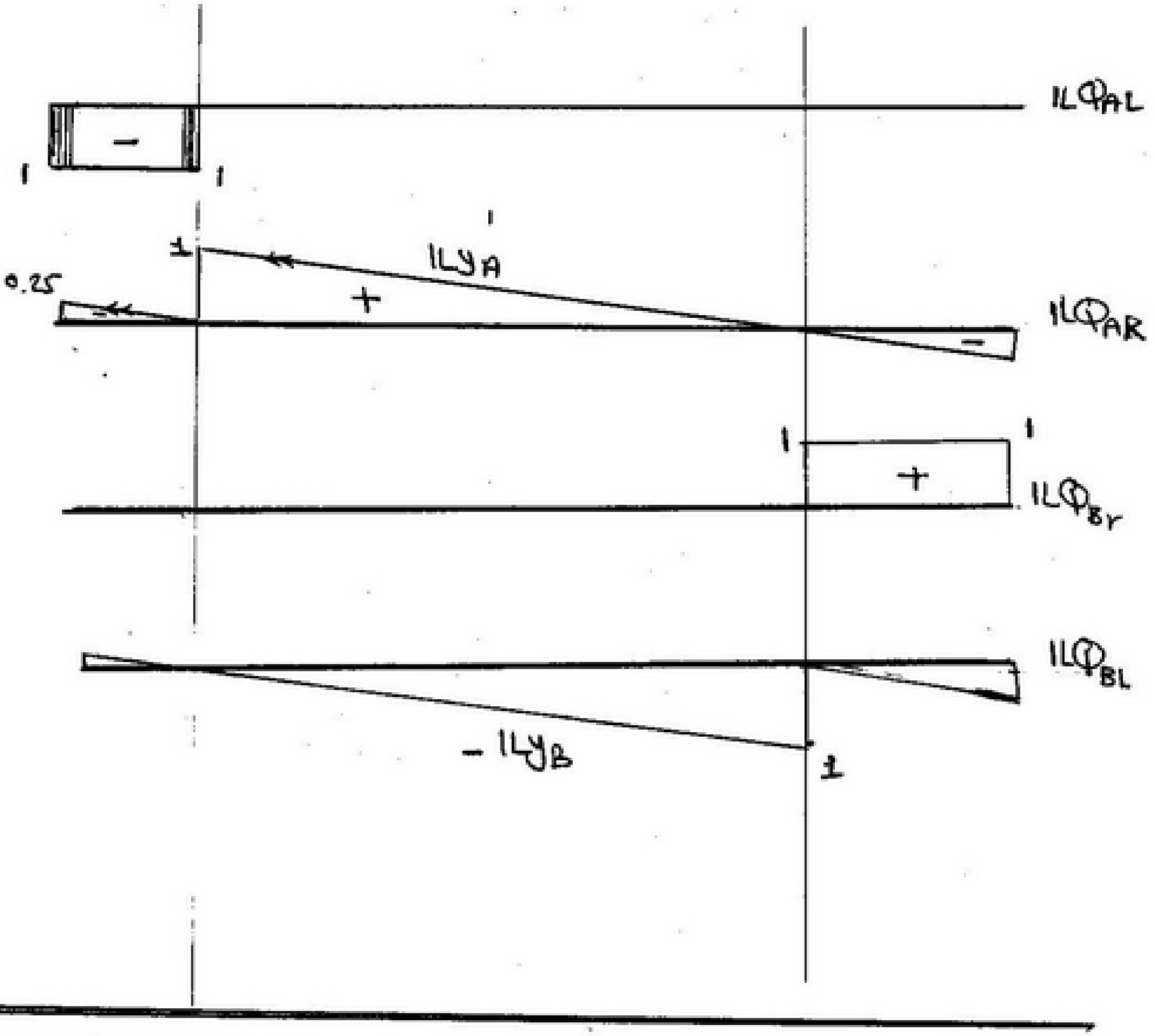

Staticaly Indeterminate Structures

المنشآت الغير محددة استاتيكياً.

لغرض بيانها وحيد المحددة استاتيكياً فإن رسم IL عليها

عبارة عن منحنيات وليس خطوط مستقيمة.

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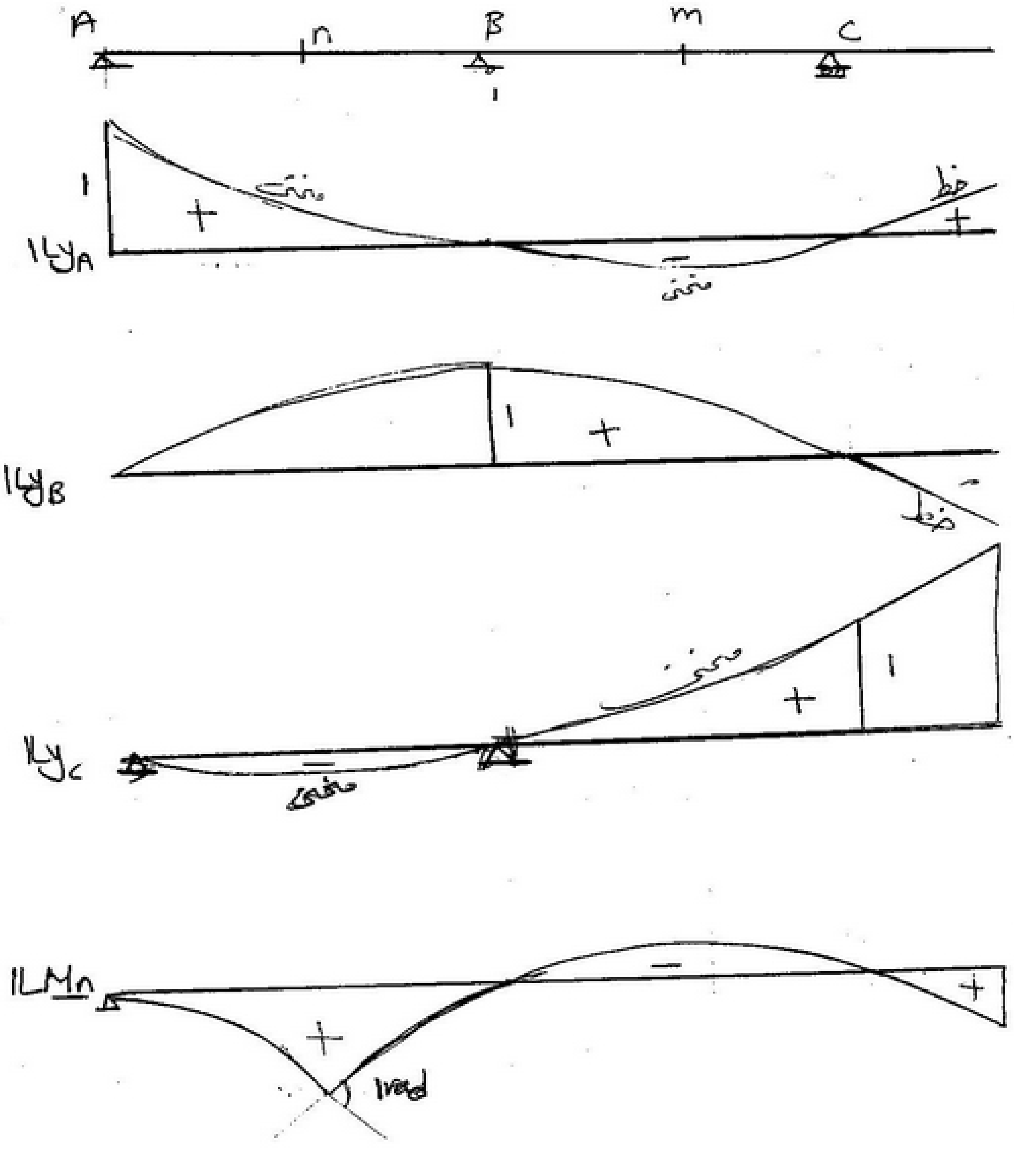

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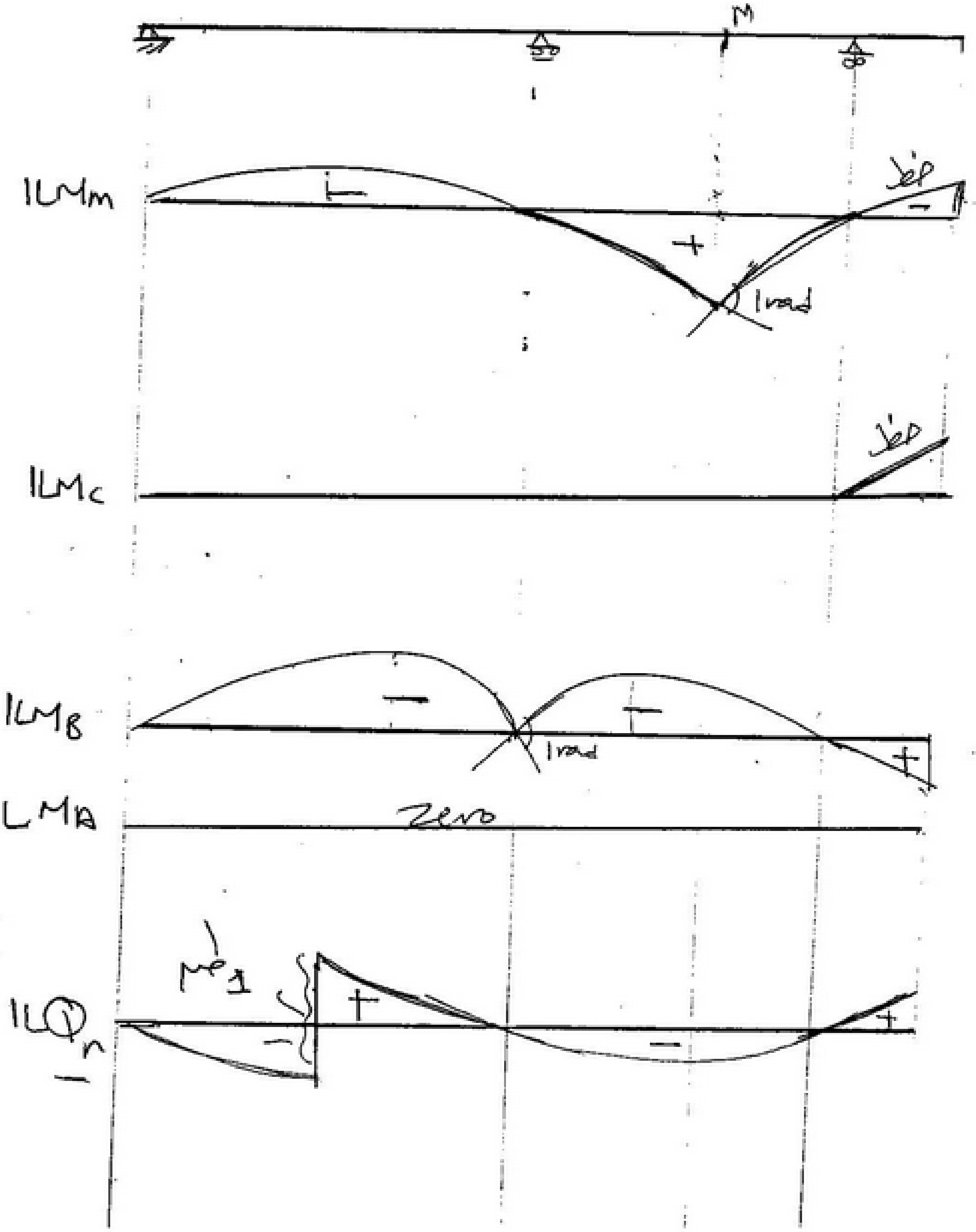

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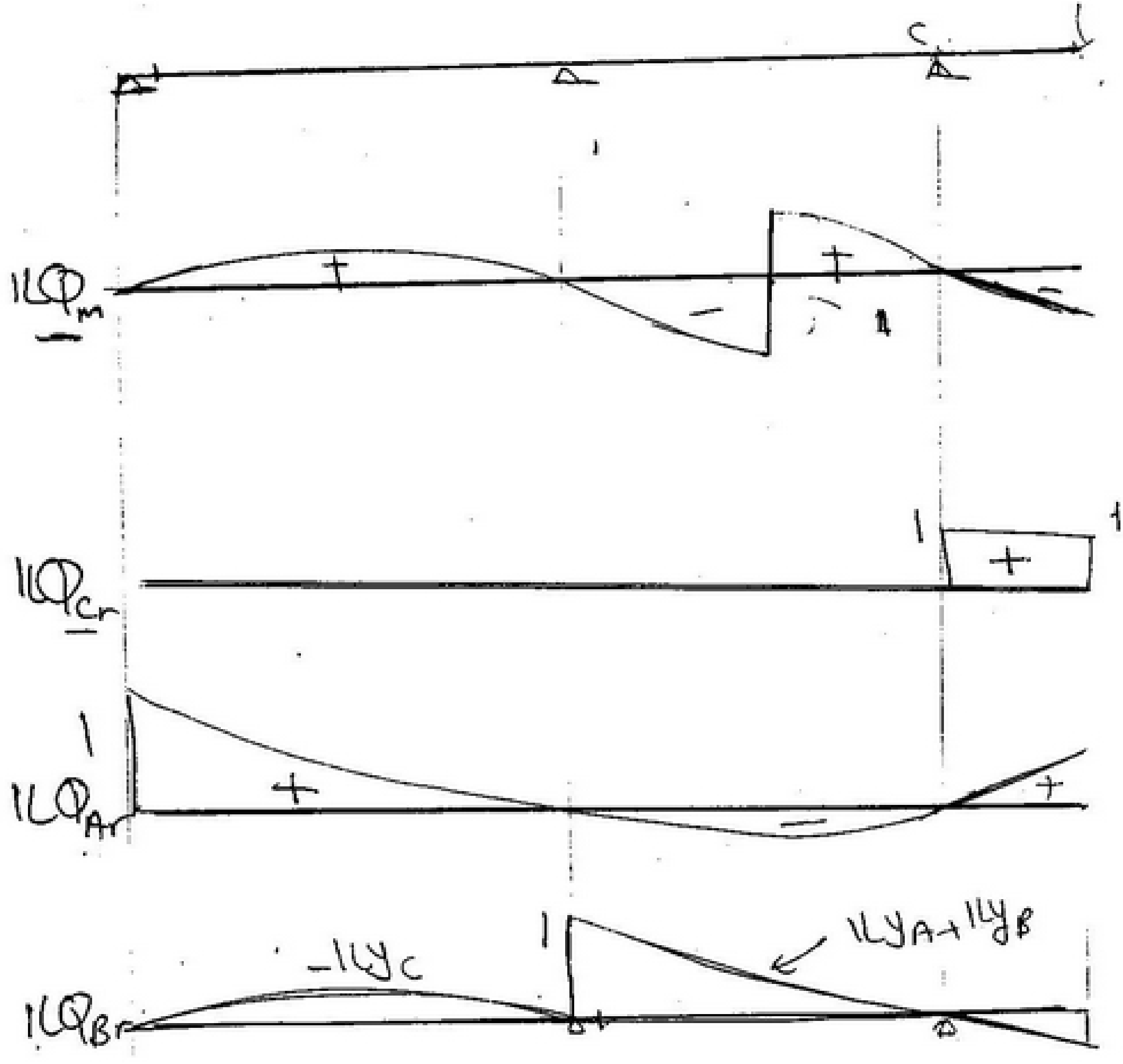
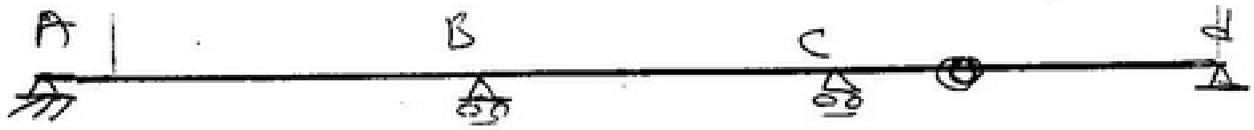


Home work



+ ILyd1

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STRUCTURE MECHANICS

2 nd Year

CIVIL

CH: INFLUENCE LINES

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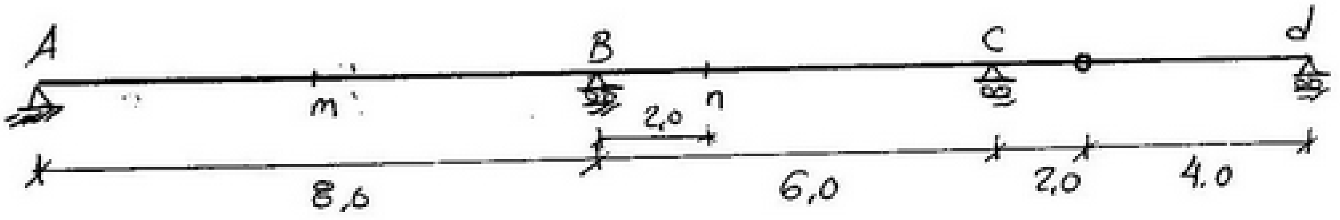
بسم الله الرحمن الرحيم

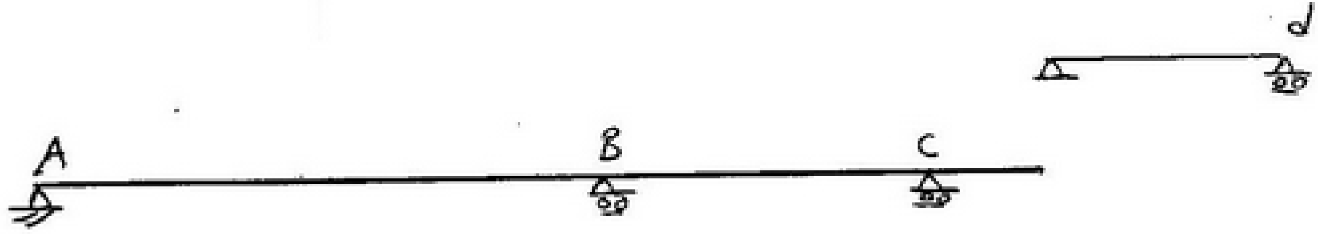
Draw the influence lines for,

- Y_A, Y_B, Y_C, Y_d.
- M_m, M_n, M_B, M_C, M_A.
- IL Q_m, Q_n, Q_{Ar}, Q_{BL}, Q_{Br}, Q_{cL}, Q_{cr}, Q_{dL}



Sol:

① لاحظ وجود جزء محدد استاتيكياً والآخر غير محدد



② حول الجزء الغير محدد استاتيكياً إلى محدد استاتيكياً عن طريق

Ⓐ تحرير رد الفعل عند (A) ← من النهاية نحصل على ILY_A

Ⓑ تحرير رد الفعل عند (B) ← من النهاية نحصل على ILY_B

Ⓒ تحرير رد الفعل عند (C) ← من النهاية نحصل على ILY_C

Ⓓ تحرير العزم عند (B) ← من النهاية نحصل على ILM_B

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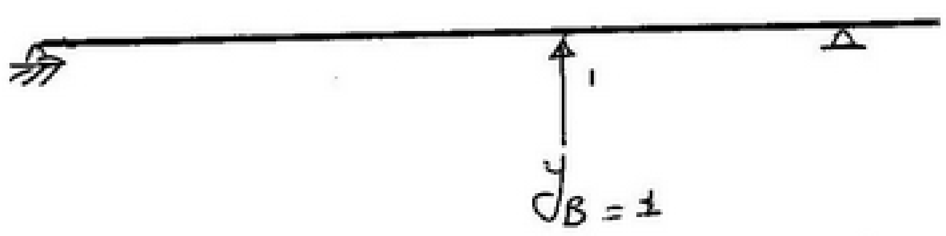
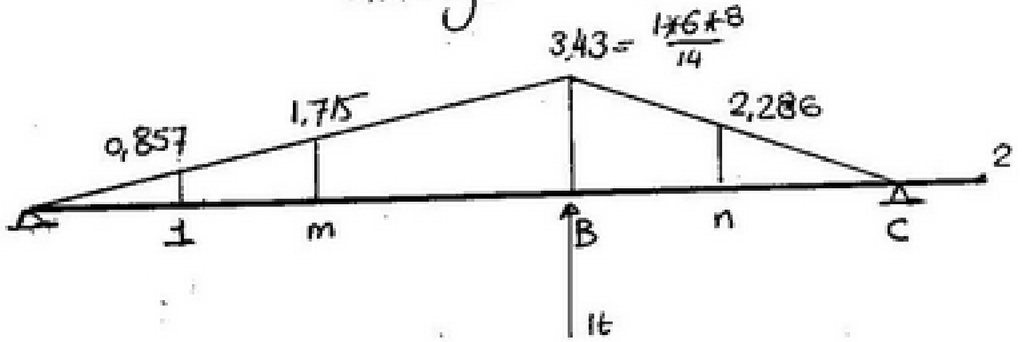
Main System

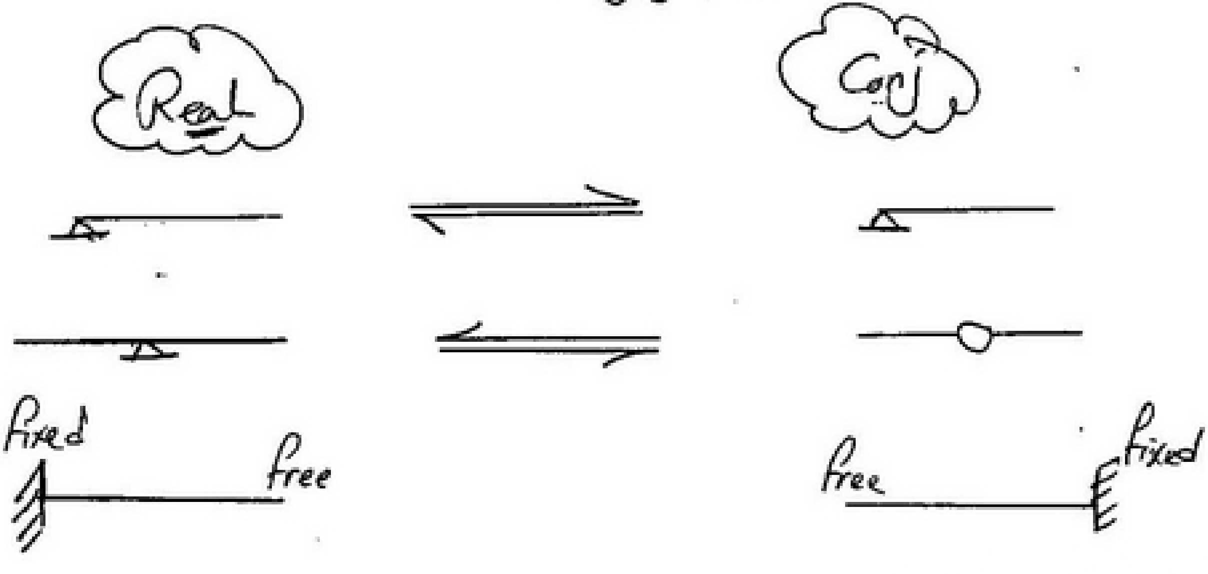


- نصفر رد الفعل عند (B) فقط (تم اختياره) ونضع بدلاً منه 1 طن لأعلى.
- نرسم العزوم نتيجة الـ (1t) على الـ main system



- نختار مجموعة من النقاط على الكمرة لإيجاد الترخيم عندها بالنسبة والتناسب بشرط أن تكون n , m منها.

- نحول الكمرة إلى Conjugate_beam



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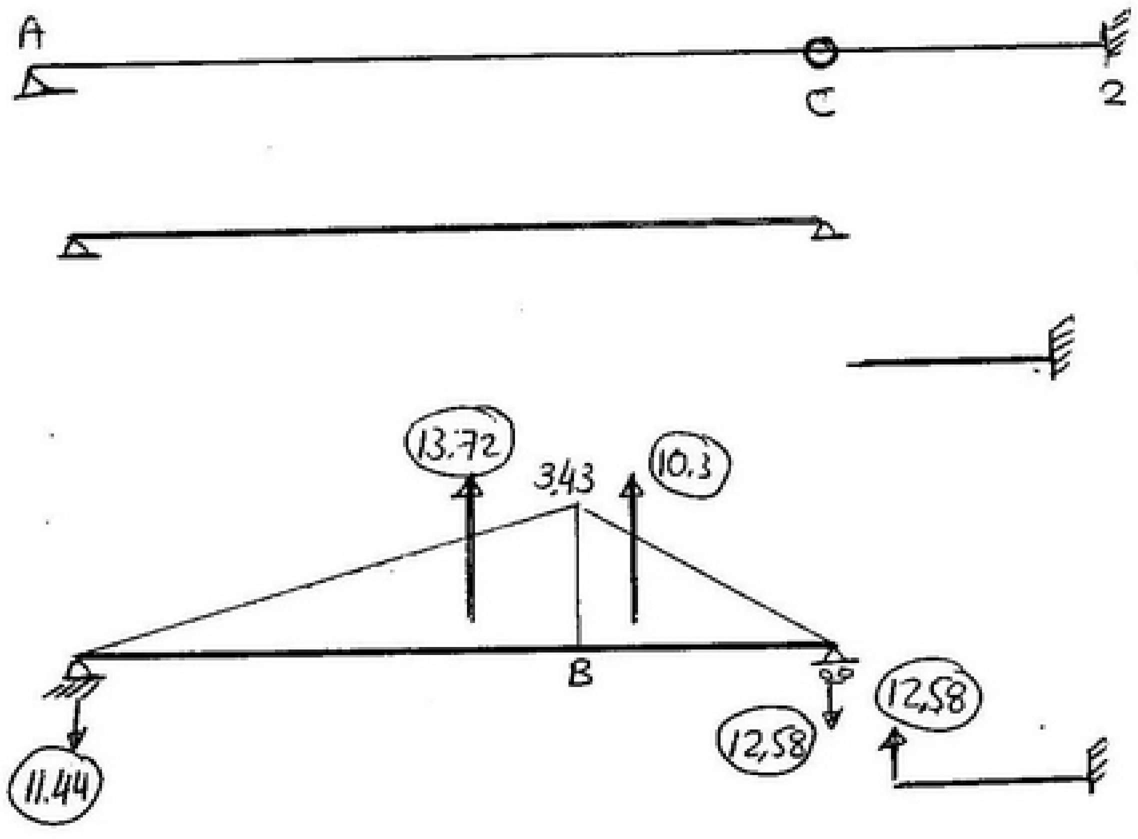
Conj, beam

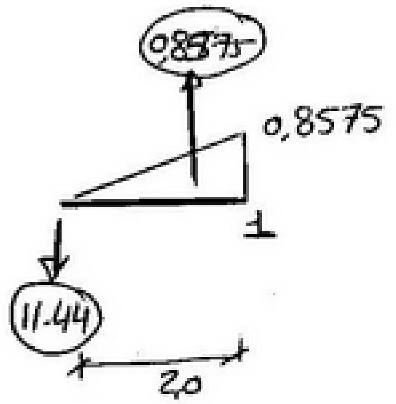


∴

تم حساب def عند النقاط المختارة

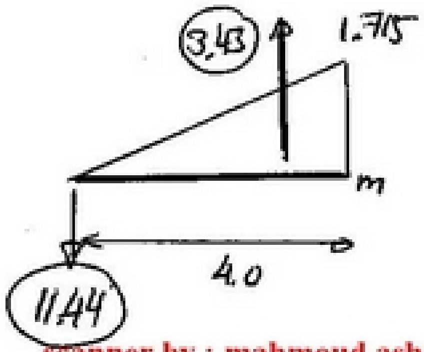
①, ⓜ, ⓝ, Ⓑ, ②

def = Elastic Moment at point



$$\delta_1 = \frac{1}{EI}\left(-11.44 * 2 + 0.85757 * 2/3\right)$$

$$\delta_1 = -\frac{22.3}{EI}$$



$$\delta_m = \frac{1}{EI}\left(-11.44 * 4 + 3.43 * 4/3\right)$$

$$\therefore \delta_m = -\frac{41.18}{EI}$$

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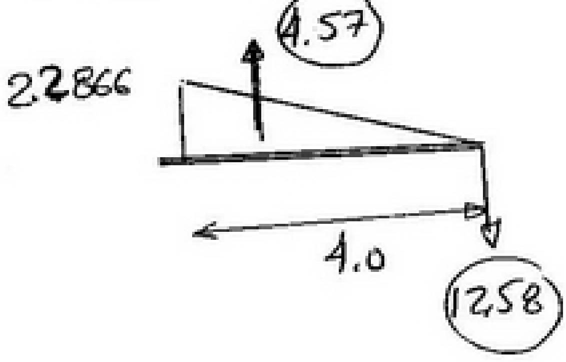
$$\delta_B = \frac{1}{EJ}\left(-11.44 * 8 + 13.72 * 8/3\right) = -\frac{54.93}{EJ}$$

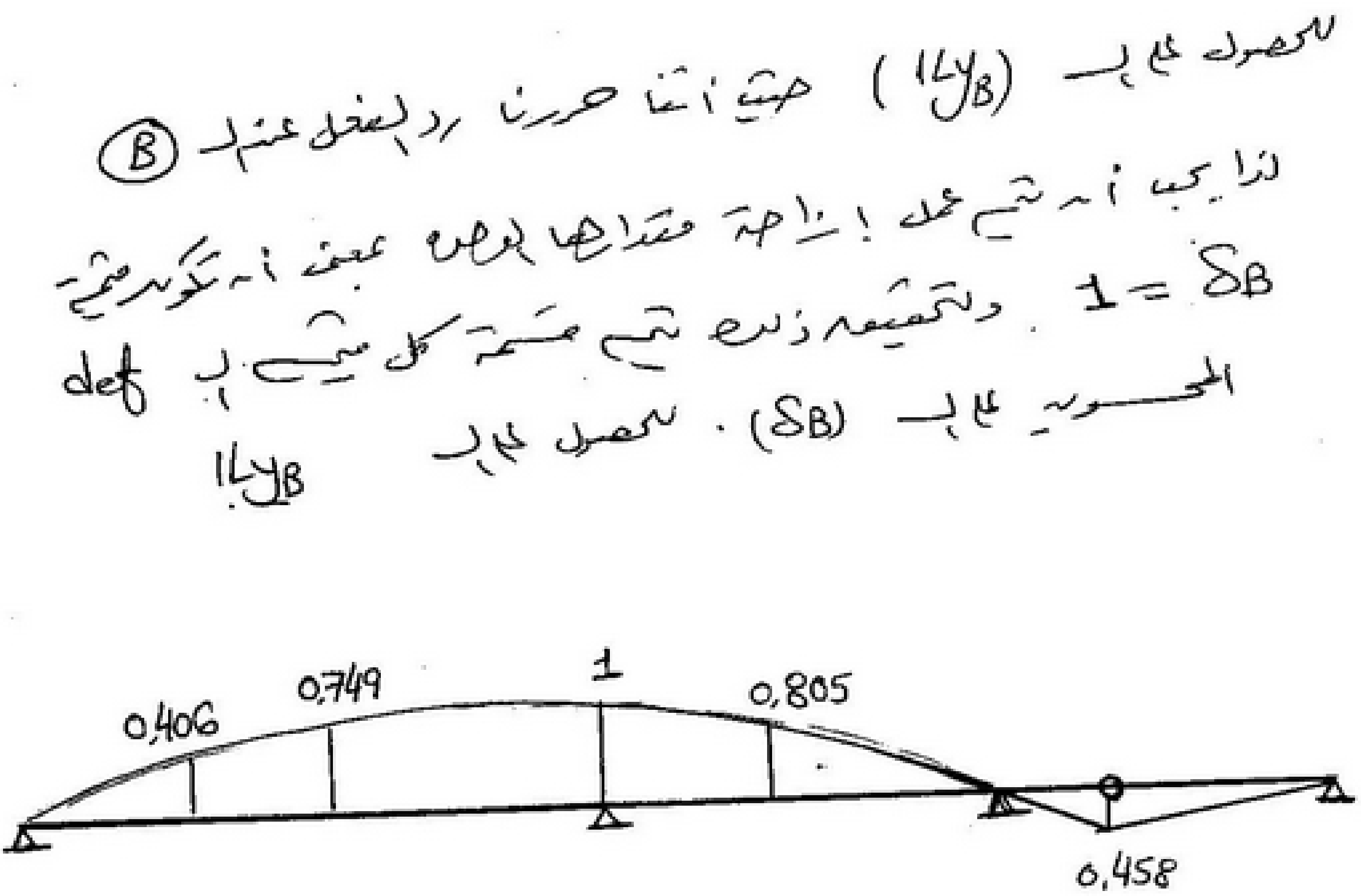
$$\delta_n = \left(-12.58 * 4 + 4.57 * 4/3\right)\frac{1}{EJ}$$

$$\delta_n = \left(-\frac{44.22}{EJ}\right)$$



$$\delta_2 = (+12.58 * 2)\frac{1}{EI} = \frac{25.16}{EJ}$$

للحصول على الـ (ILy_B) حيث أننا حررنا رد الفعل عند (B) لذا يجب أن يتم عمل إزاحة مقدارها الوحدة بمعنى أن تكون قيمة $\delta_B = 1$. ولتحقيق ذلك يتم قسمة كل شيء بالـ def المحسوبة عند الـ (δ_B) . نحصل على الـ ILy_B



(ILy_B)

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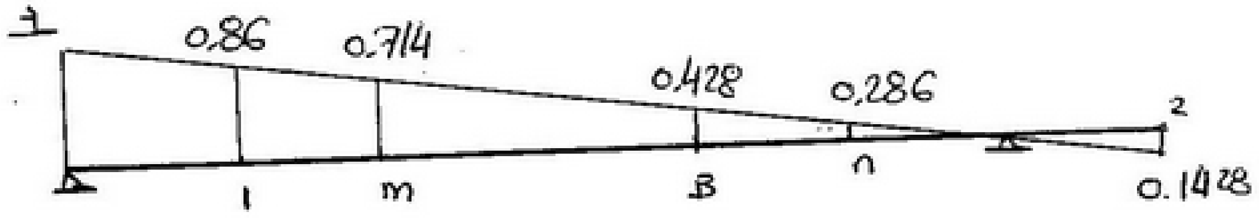
للحصول على أى (IL) نستخدم الـ (ILy_B) وكذلك الـ (main syst)

يعنى : Ⓟ على الـ main sys ارسم الـ IL المطلوب وكمان

المبدئى أو Node Initial

مثال

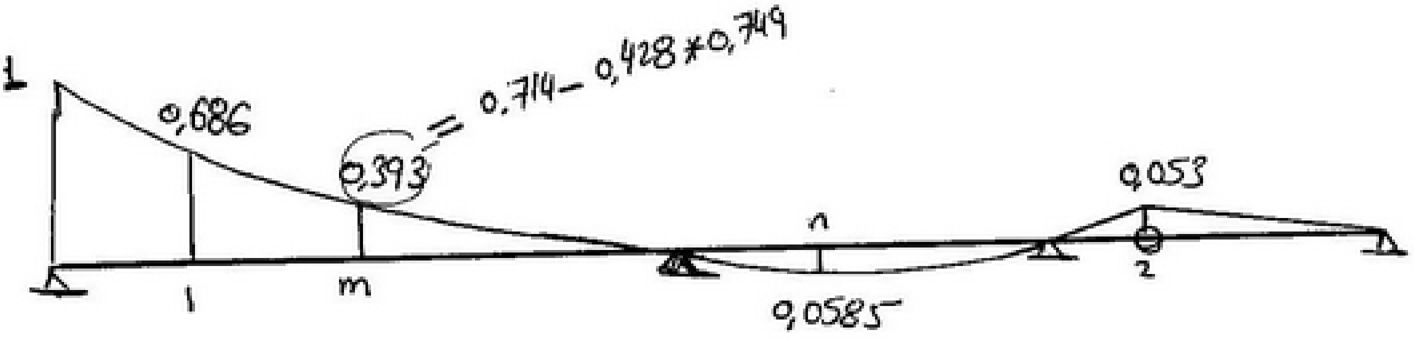
(ILy_A)



(ILy_{Ao})

يقسم القيمة عند Ⓑ = 0,428

$$\therefore \quad ILy_A = ILy_{Ao} - 0.428 * (ILy_B)$$



(ILy_A)

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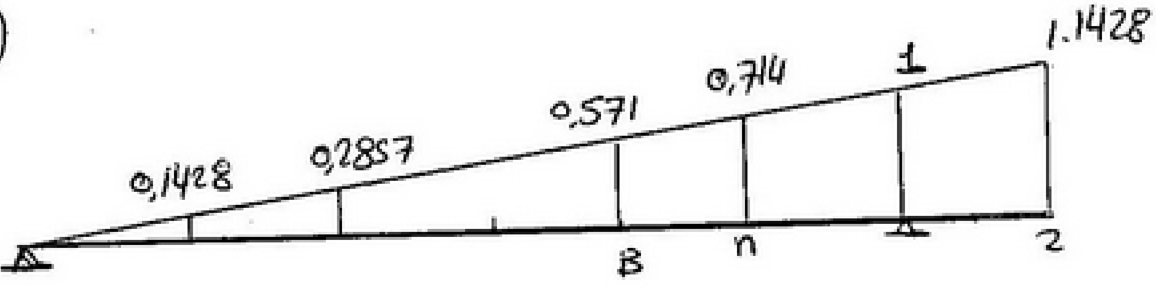
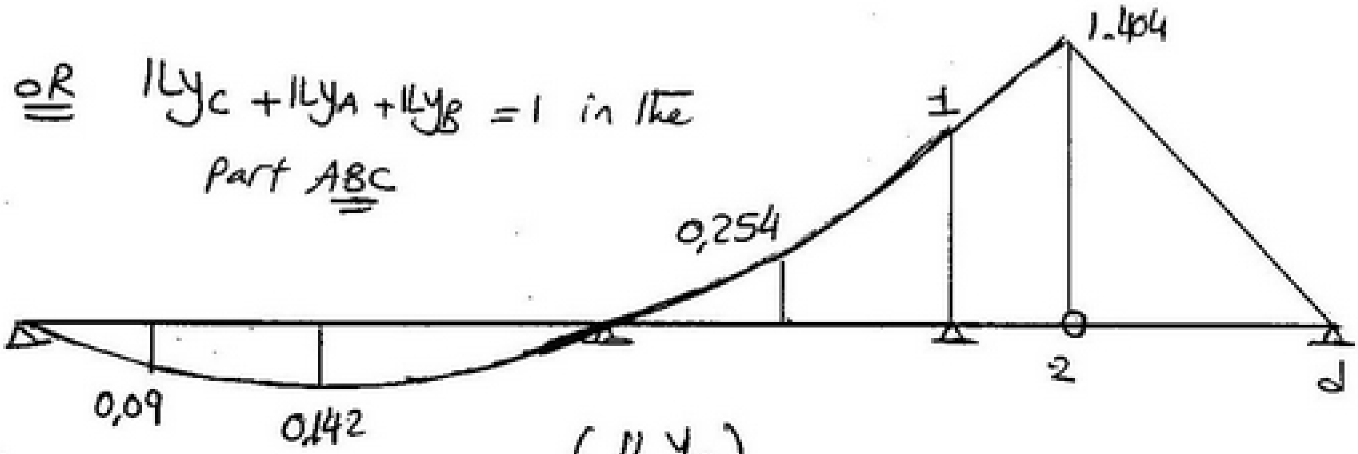
ILy_c



(ILy_{co})

$$\therefore \quad ILy_c = ILy_{co} - 0,571 * ILy_B$$

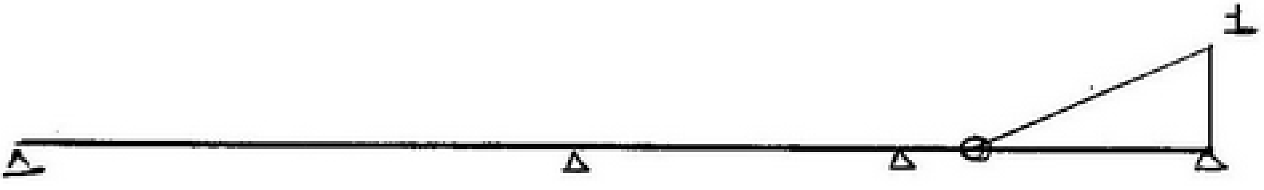
OR $ILy_c + ILy_A + ILy_B = 1$ in the part ABC



(ILy_c)

ILy_d

كده اسهل شكل



(ILy_d)

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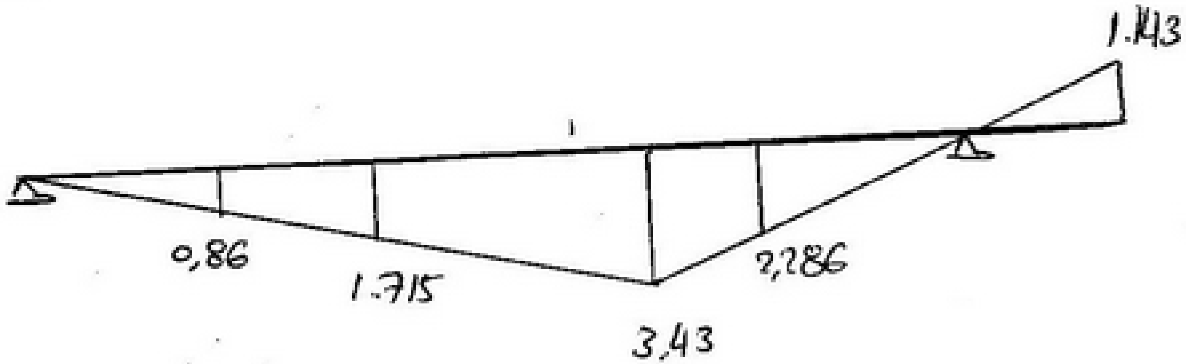
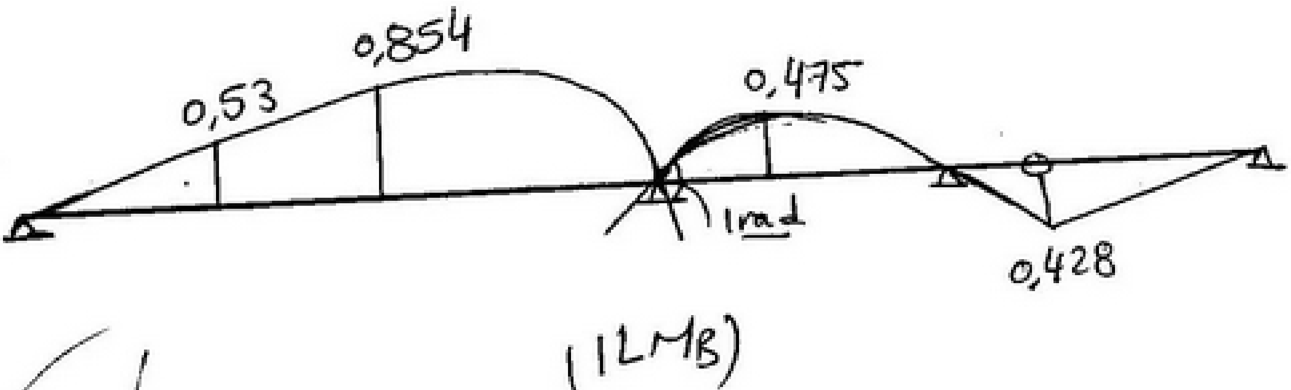
ILM$_B$

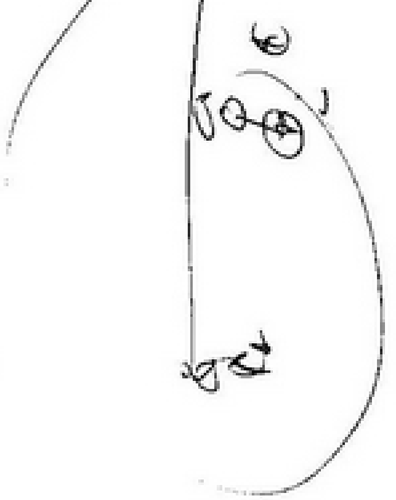


$(ILM_B)_0$

$$ILM_B = (ILM_B)_0 - 3{,}43\,(ILY_B)$$



(ILM_B)



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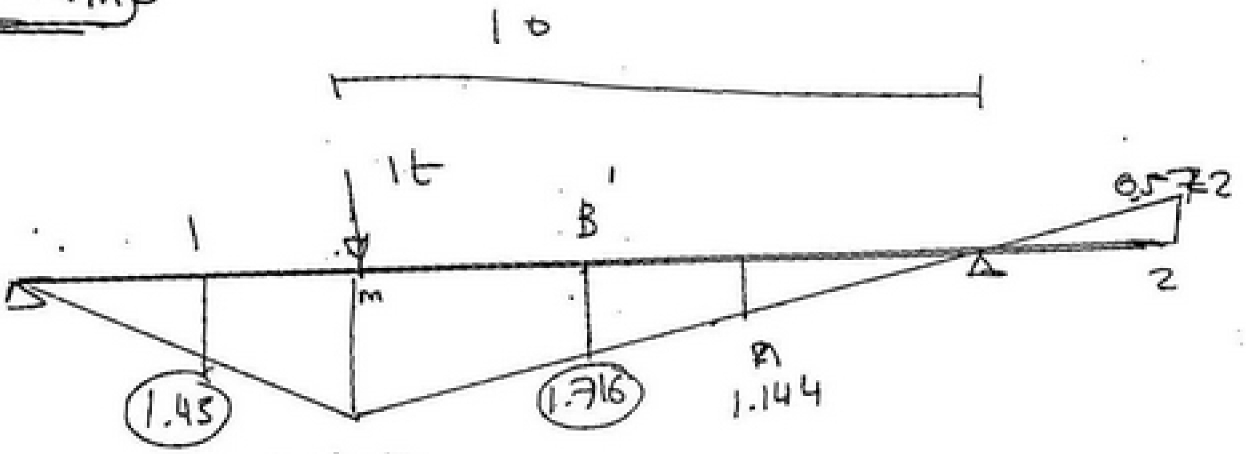
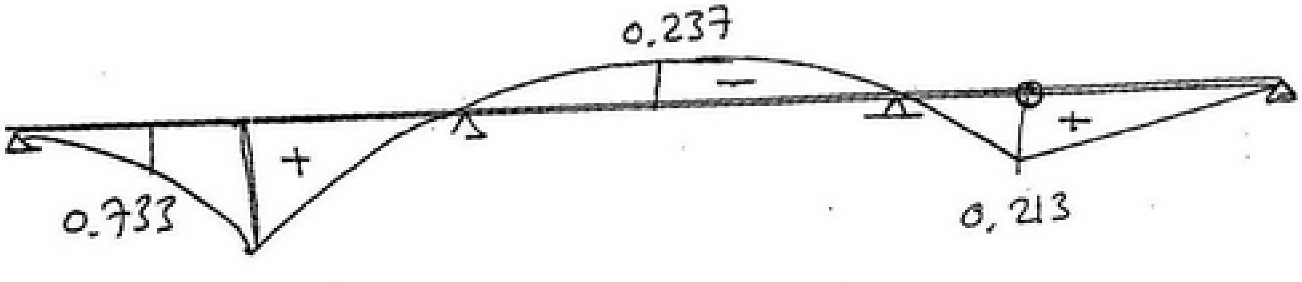
IL Mm



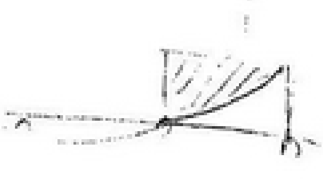
$\frac{1 \times 4 \times 10}{14} = 2.86$

(IL Mm)o

$$IL\ M_m = IL\ M_{no} - (IL\ y_B) * 1.716$$



(IL Mm)



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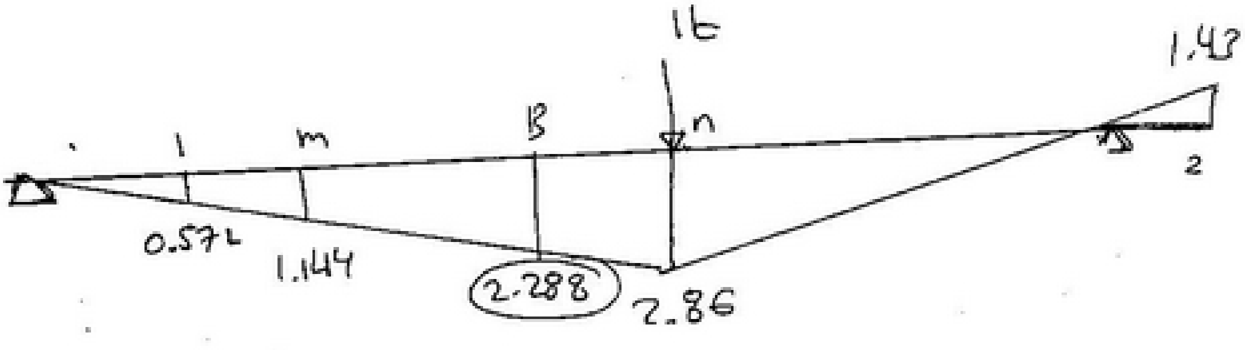
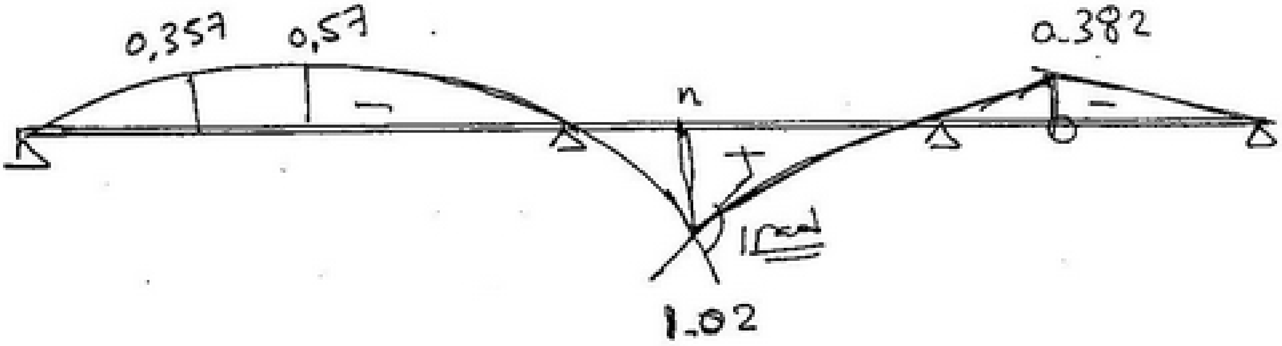
IL Mn



$$IL\,M_n = IL\,M_{n_0} - 2.288 * (IL\,Y_B)$$



(IL Mn)

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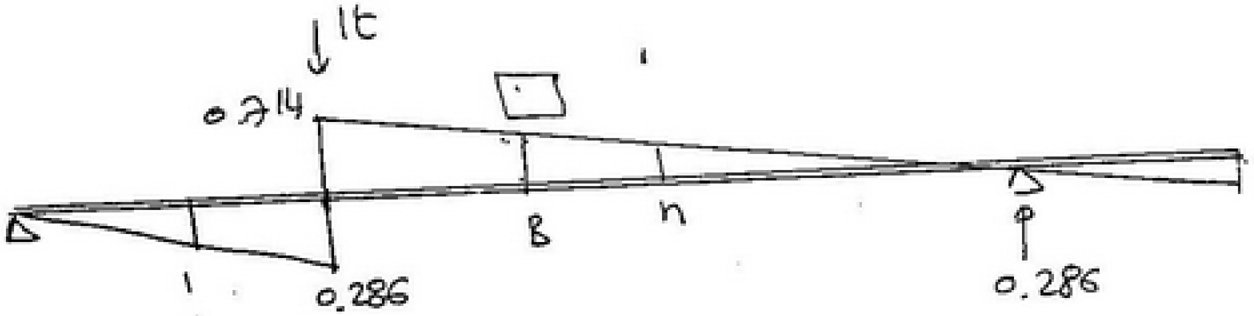
$IL\,Q_m$

$IL\,Q_o$ عكس ـ ر ب



$IL\,Q_{mo}$

$$IL\,Q_m = IL\,Q_{mo} - \square\; IL\,y_B$$

OR

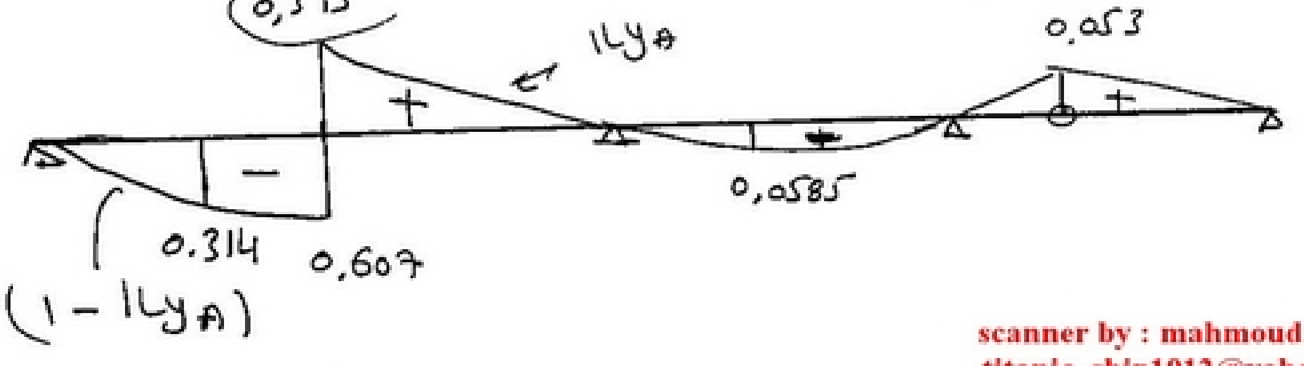
Load A → M

$$IL\,Q_m = -\left(IL\,y_B + IL\,y_C + IL\,y_d\right)$$

$$= 1 - IL\,y_A$$

Load . M → d

$$IL\,Q_m = IL\,y_A$$



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ILQ_n

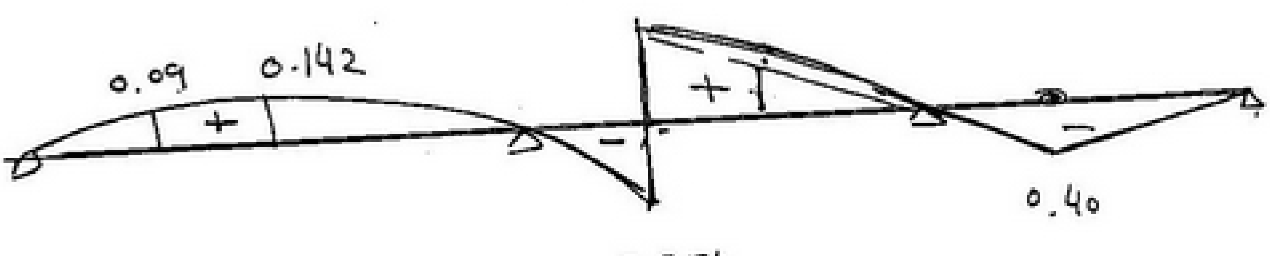
ابحث في main system كـ سين : د

load A ⟶ n

$$ILQ_n = -(IL\,y_c + IL\,y_d)$$

load n ⟶ d

$$IL\,y_A + IL\,y_B = ILQ_n$$



(ILQ_n)

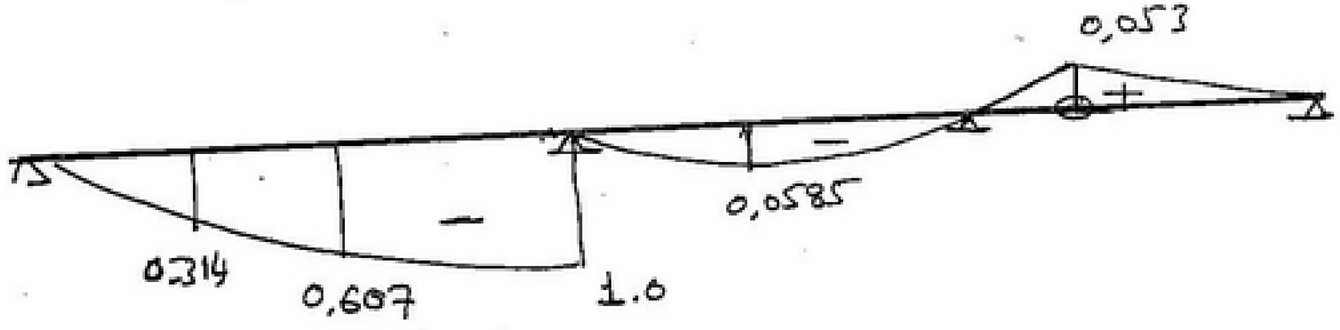
IL Q_{BL}

Load A → B_L

$$IL\,Q_{BL} = -(IL\,y_B + IL\,y_C + IL\,y_d)$$
$$= (1 - IL\,y_A)$$

Load B_L → d

$$IL\,Q_{BL} = IL\,y_A$$



(IL Q_{BL})

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titanic_ship1912@yahoo.com

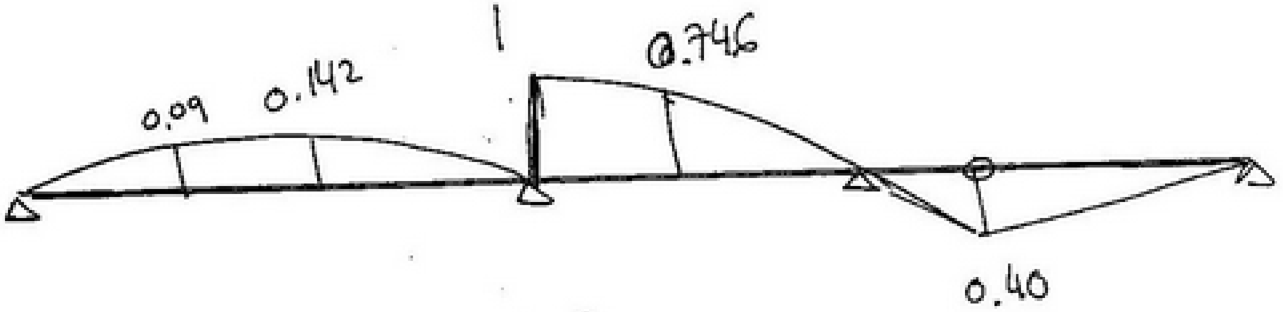
$IL Q_{Br}$

Load $A \rightarrow B_r$

$$IL Q_{Br} = -(IL y_c + IL y_d)$$

Load $B_r \rightarrow d$

$$IL Q_{Br} = IL y_A + IL y_B$$

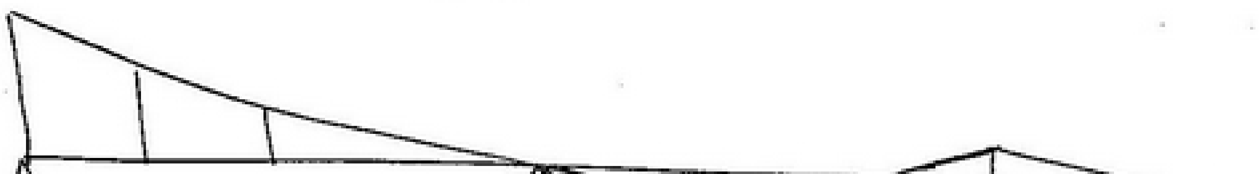


$IL Q_{Br}$

$IL Q_{Ar}$

$A_r \longrightarrow d$

$$IL Q_{Ar} = IL y_A$$



$IL Q_{Ar}$

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STRUCTURE MECHANICS

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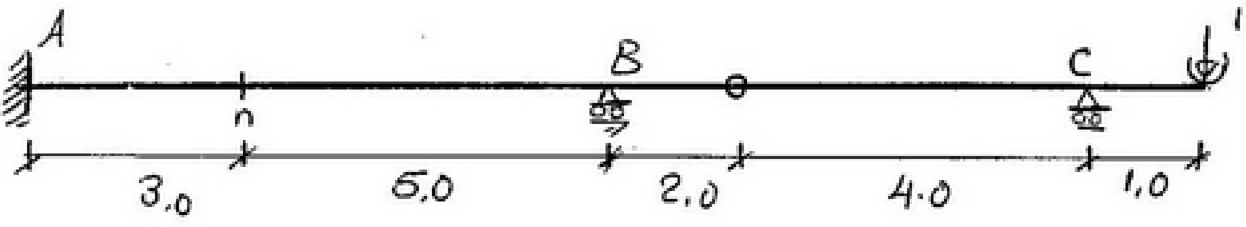
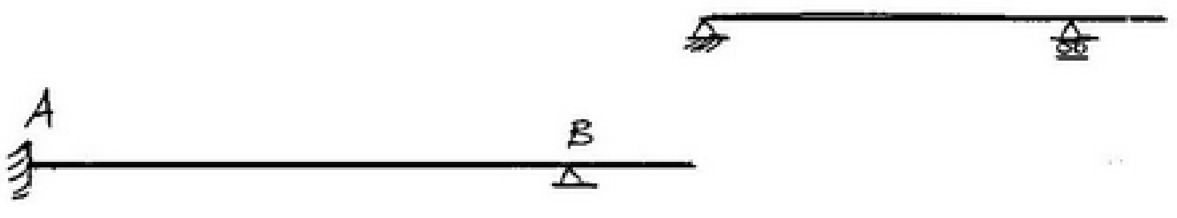
بسم الله الرحمن الرحيم

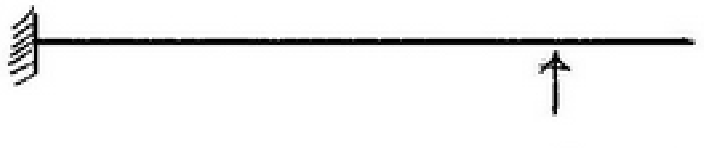
For the shown continous beam, draw the influence line

for
- Y_A, Y_B, Y_C
- M_B, M_A, M_n
- Q_n, Q_{Br}, Q_{BL}





main system



$X_1 = 0.0$

Put $X_1 = 1t$

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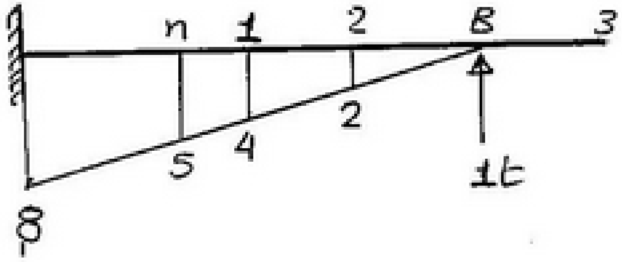
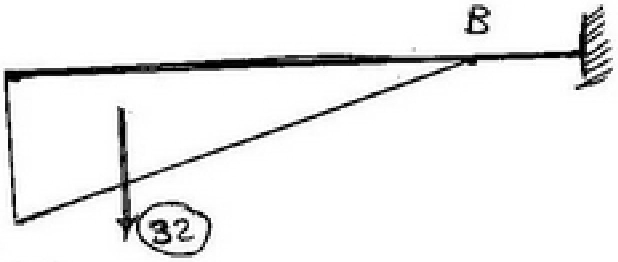
B.M.D



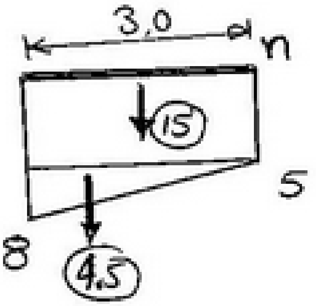
Conj Beam



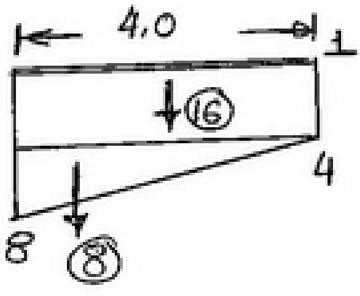
Calculate def at points n, 1, 2, 3, B

$$\delta_B = -32 * \frac{2}{3}(8) = -170.67/EI$$

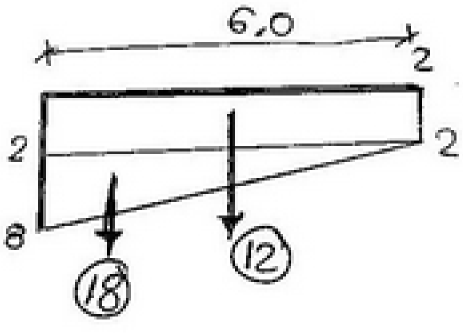
$$\delta_n = \frac{1}{EI}\left(-15 * 1.5 - 4.5 * 2\right) = -31.5/EI$$



$$\delta_1 = \frac{1}{EI}\left(-16 * 2 - 8 * \frac{2}{3}(4)\right) = -53.33/EI$$



$$\delta_2 = \frac{1}{EI}\left(-18 * 4 - 12 * 3\right) = -108/EI$$



$$\delta_3 = \frac{1}{EI}\left(-32 * \left(\frac{2}{3} * 8 + 2\right)\right) = -\frac{234.67}{EI}$$

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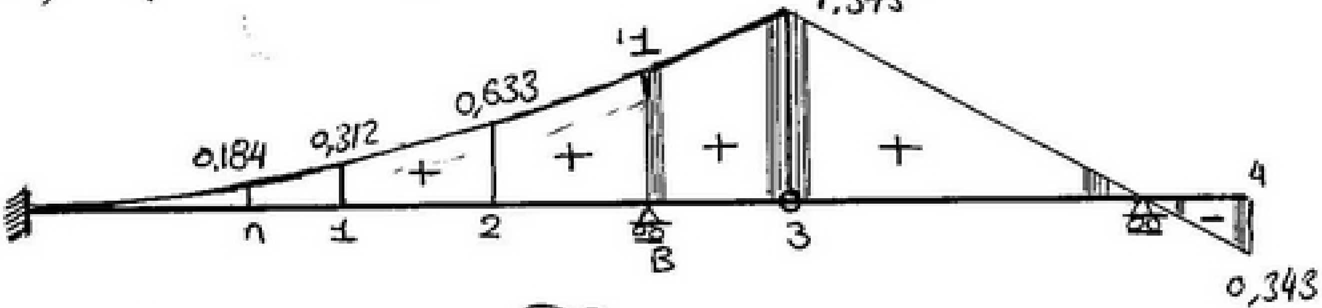
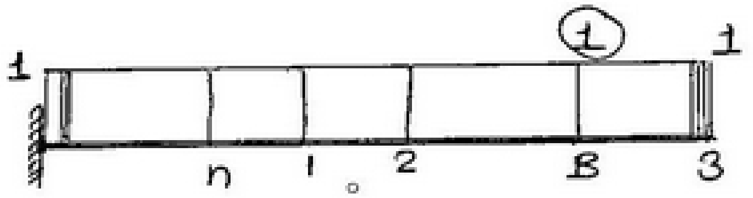
ILy_B

للحصول على ILy_B يتم قسمة كل δ على (δ_B)



ILy_B

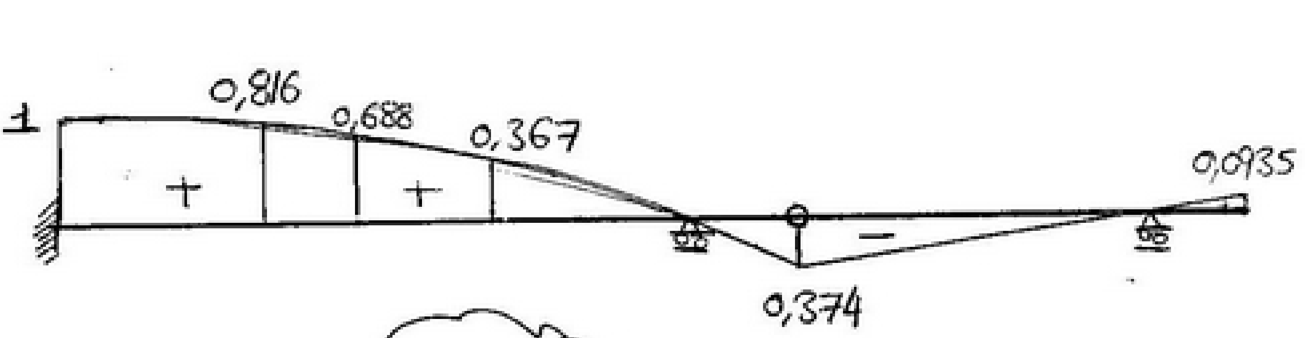
ILy_A



$(ILy_A)_0$

$$ILy_A = ILy_{A0} - 1 * ILy_B$$

$$ILy_A = 1 - ILy_B$$



ILy_A

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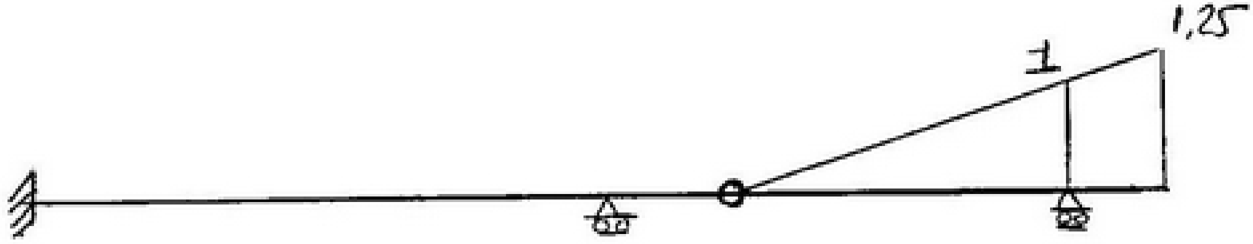
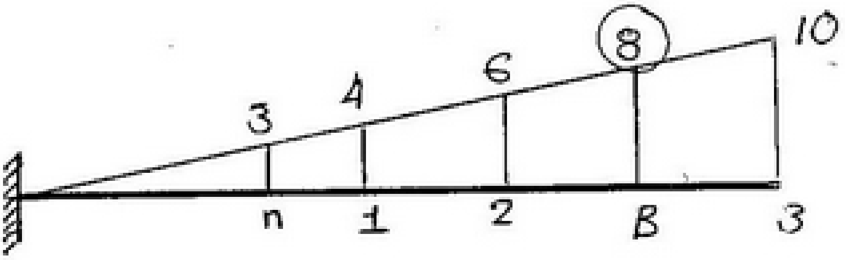
$IL\,y_c$

الجزء الواقع به الركيزة (C) محدد استاتيكياً



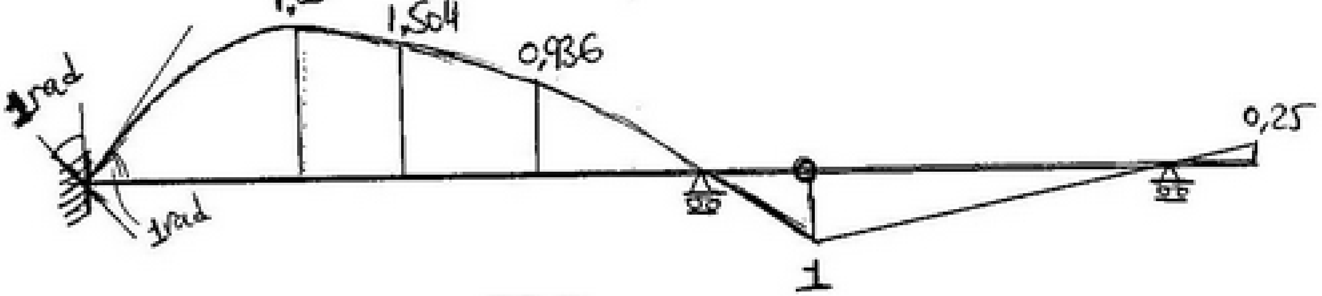
$(IL\,y_c)$

$IL\,M_A$



$(IL\,M_A)_0$

$$IL\,M_A = (IL\,M_A)_0 - 8 \times IL(y_B)$$



$IL\,M_A$

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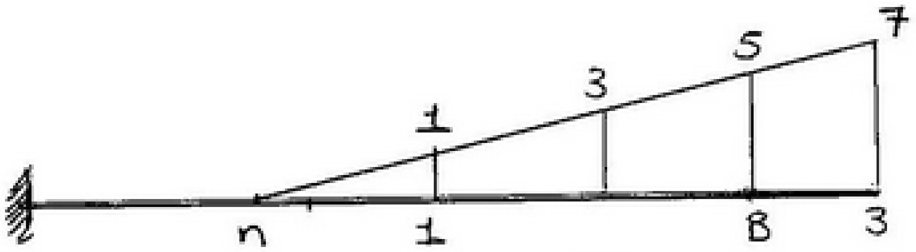
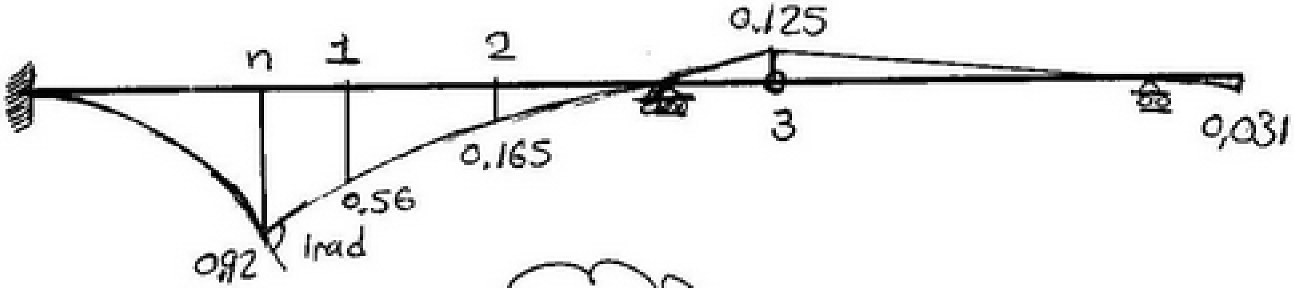
IL M_n



$(IL\ M_{no})$

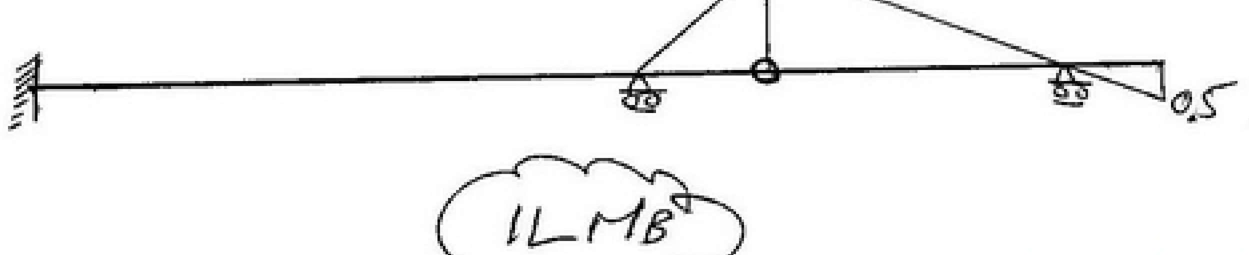
$$IL\ M_n = IL\ M_{no} - 5 * IL\ y_B$$



IL M_n

IL M_B

لاحظ انه يوجد جزء محددا استاتيكيا
يعين بركيزه (B)



IL M_B

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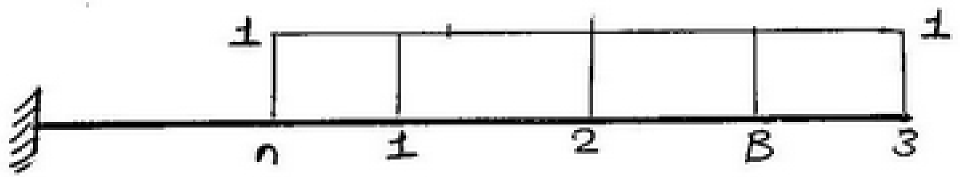
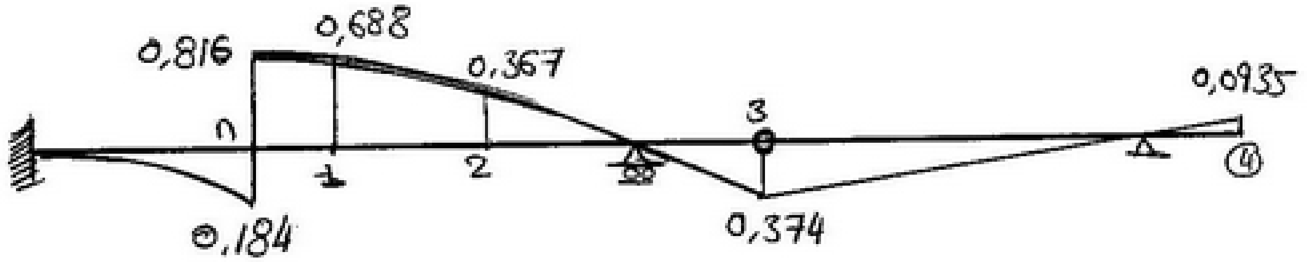
$IL\,Q_n$

ممكن ارسم الـ $(IL\,Q_n)_o$ عادى جداً جداً



$(IL\,Q_n)_o$

$$IL\,Q_n = IL\,Q_{n\,o} - 1 \times IL\,y_B$$



OR

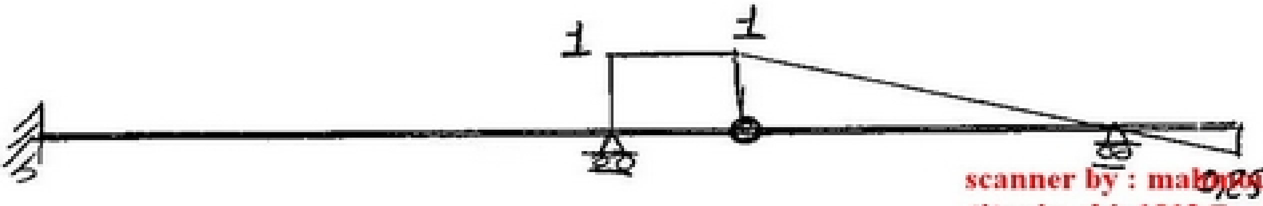
Load $n \rightarrow$ point ④

$$IL\,Q_n = IL\,y_A$$

Load $A \rightarrow n$

$$IL\,Q_n = IL\,y_A - 1$$

$IL\,Q_{Br}$



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$IL\,\Phi_{BL}$

بالمثل عكس رسم ال $(IL\,\Phi_{BL})_0$ عادي جداً

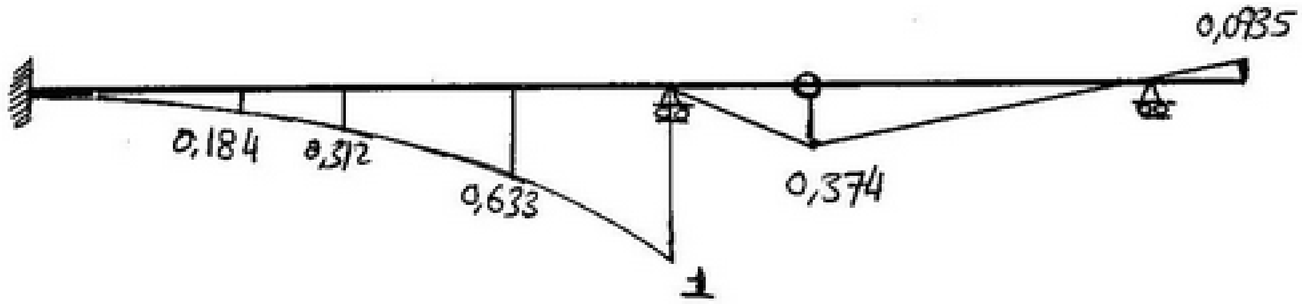
أو استثمار وجود ال IL reactions

load $B_L \longrightarrow$ point ④

$$IL\,\Phi_{BL} = IL\,y_A$$

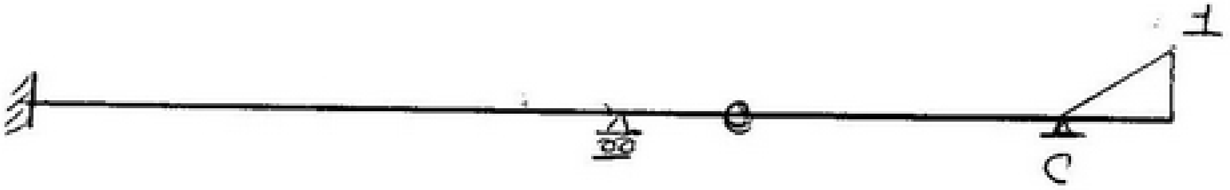
load $A \longrightarrow B_L$

$$IL\,\Phi_{BL} = IL\,y_A - 1$$



$IL\,\Phi_{BL}$

$IL\,M_c$



$(IL\,M_c)$

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STRUCTURE MECHANICS

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CIVIL

CH: INFLUENCE LINES

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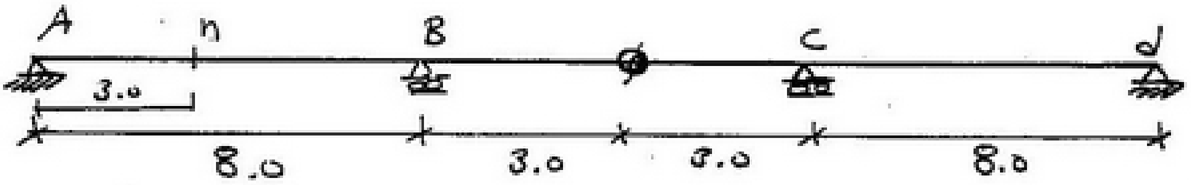
بسم الله الرحمن الرحيم

Calc

- IL y_A, y_B, y_C, y_d
- ILM_B, ILM_n
- IL Q_n, Q_{Bl}, Q_{Br}



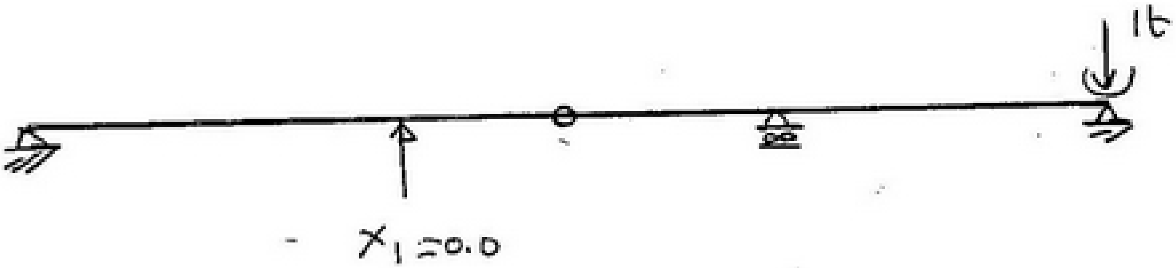
Sol =

- نلاحظ : المنشأة غير محددة استاتيكياً من الدرجة الأولى

← المنشأة متماثلة .

$y_B = y_C$ & $y_A = y_d$

← لم نستطع فصل المنشأ إلى جزئين .



(main system)

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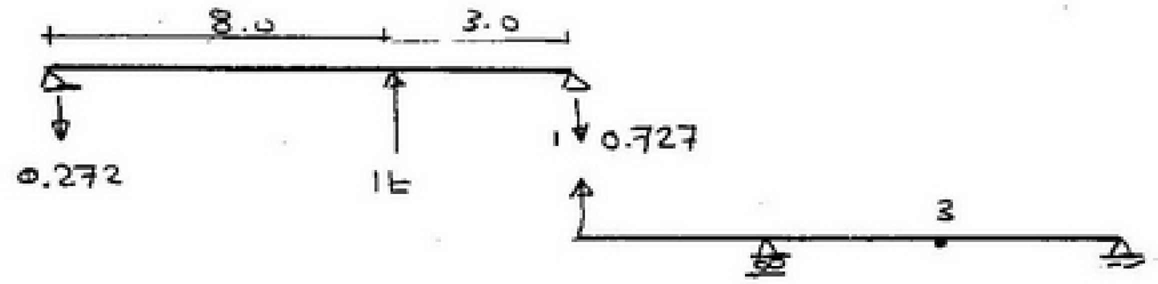
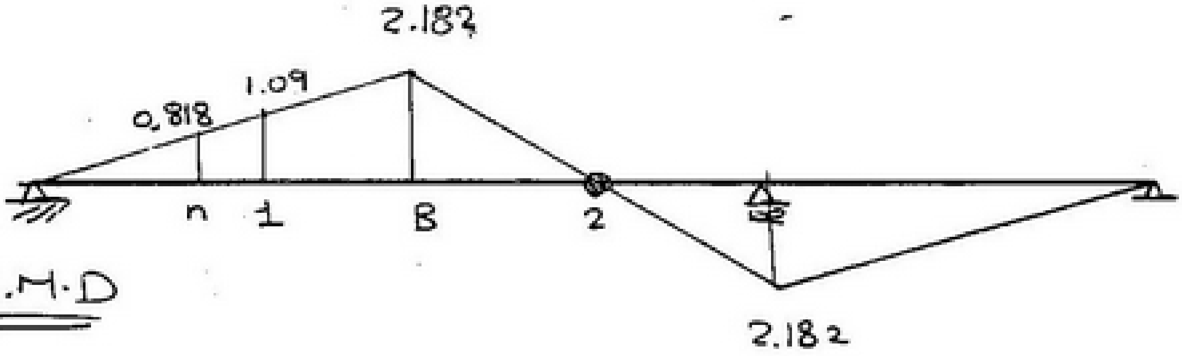
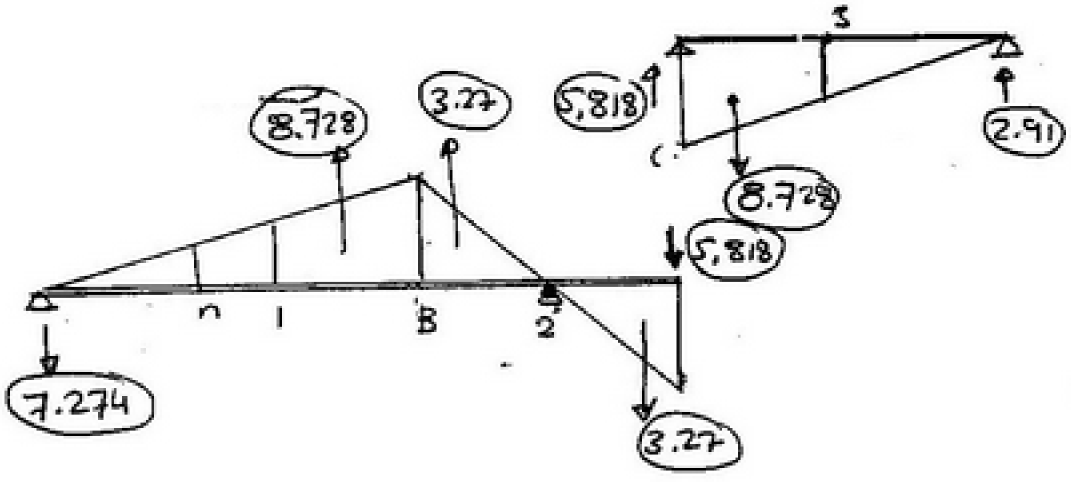




B.M.D

Conj beam



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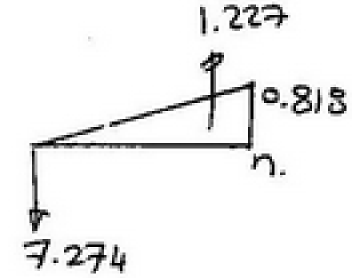
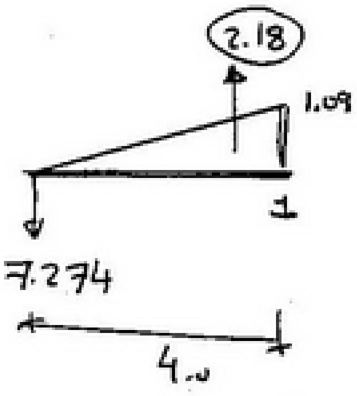
$$\delta_B = -7.274 * 8 + 8.728 * \frac{8}{3} = -34.89$$

$$\delta_2 = -5.818 * 3 - 3.27 * 2 = -24$$

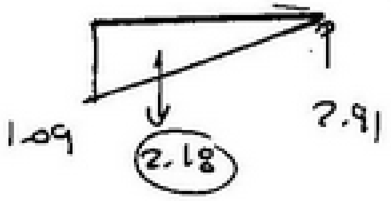
$$\delta_n = -7.274 * 3 + 1.227 * 1 = -20.6$$



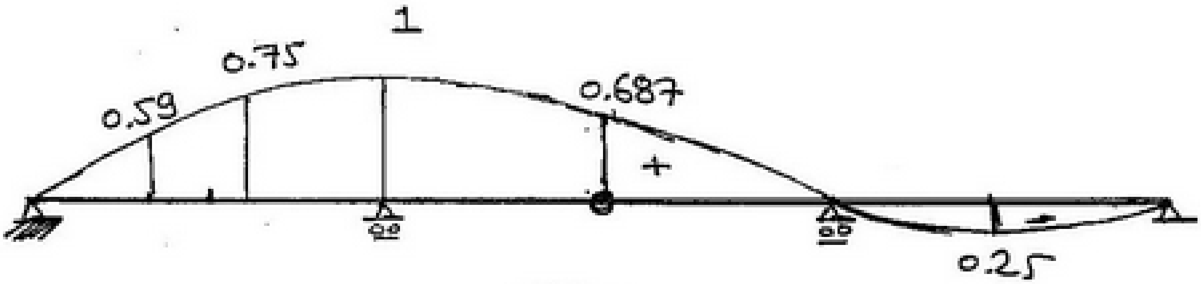
$$\delta_1 = -7.274 * 4 + 2.18 * 4/3 = -26.19$$



$$\delta_3 = 2.91 * 4 - 2.18 * 4/3 = +8.73$$



نحصل ع ١ ، (ILy_B) ثم نرسمه
بالقسمة ع (δB)



(ILy_B)

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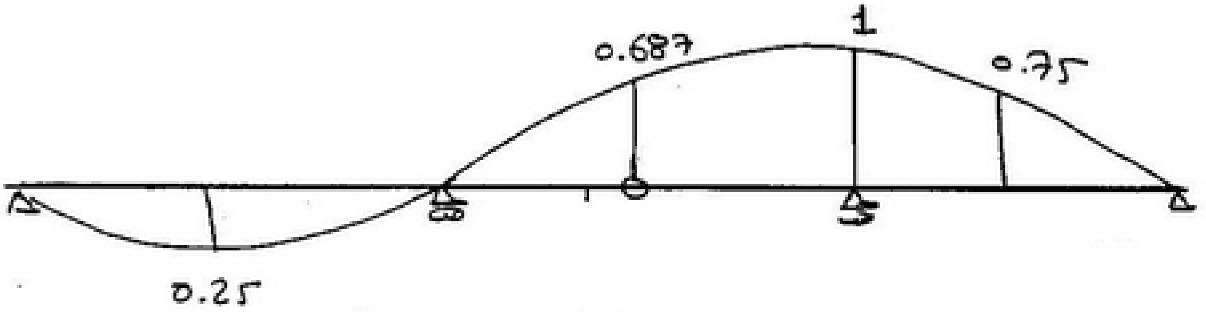
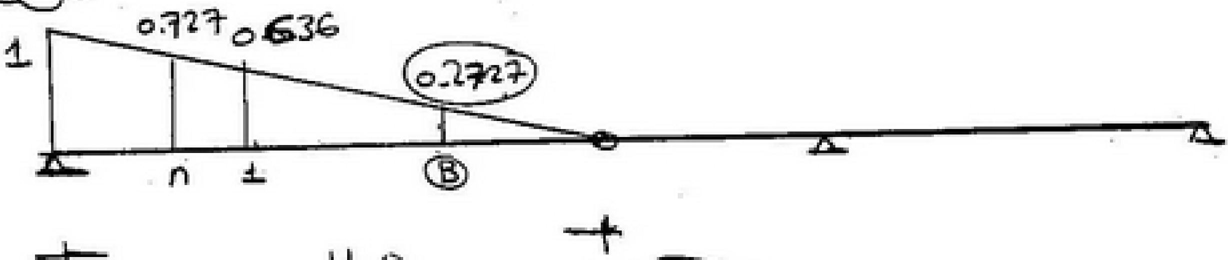


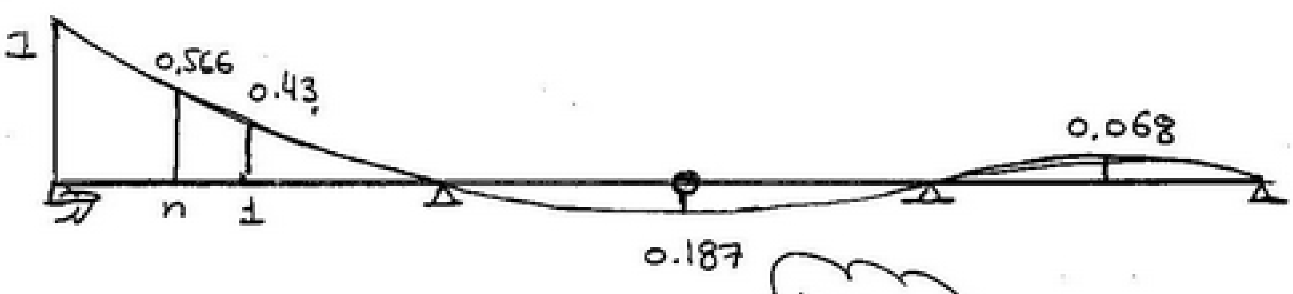
(ILy_C)

ILy_A



ILy_{A_0}

$$ILy_A = ILy_{A_0} - 0.2727\ ILy_B$$



ILy_A

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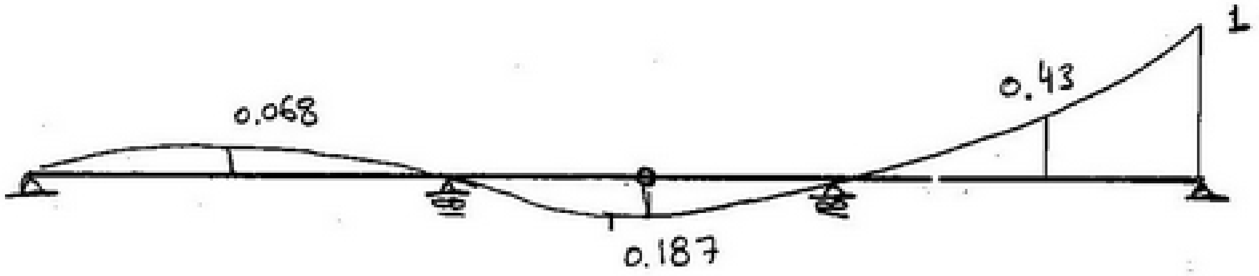
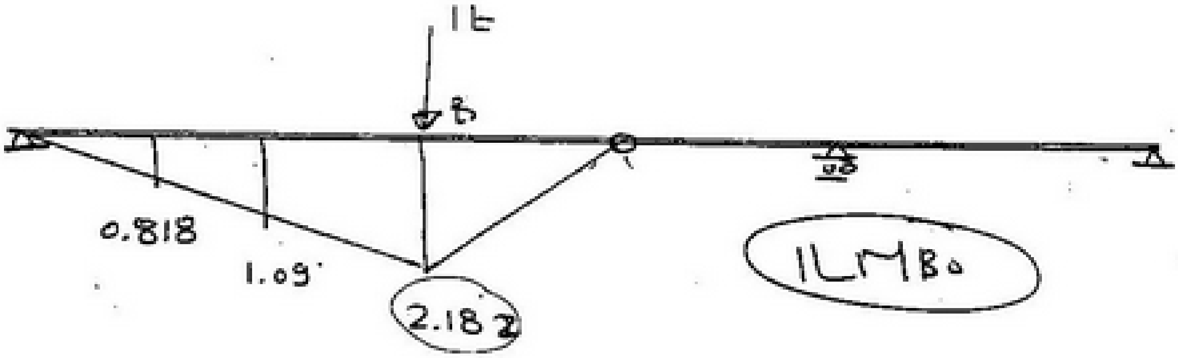
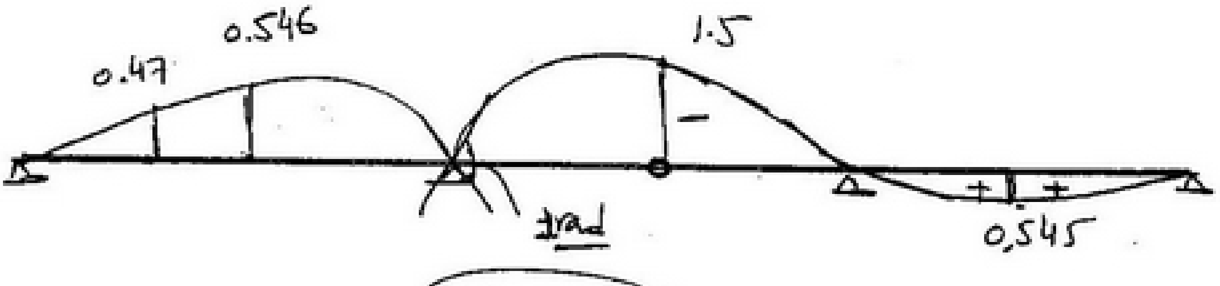


$(IL\,y_d)$

$IL\,M_B$



$$IL\,M_B = IL\,M_{B0} - 2.182 \times IL\,y_B$$



$IL\,M_B$

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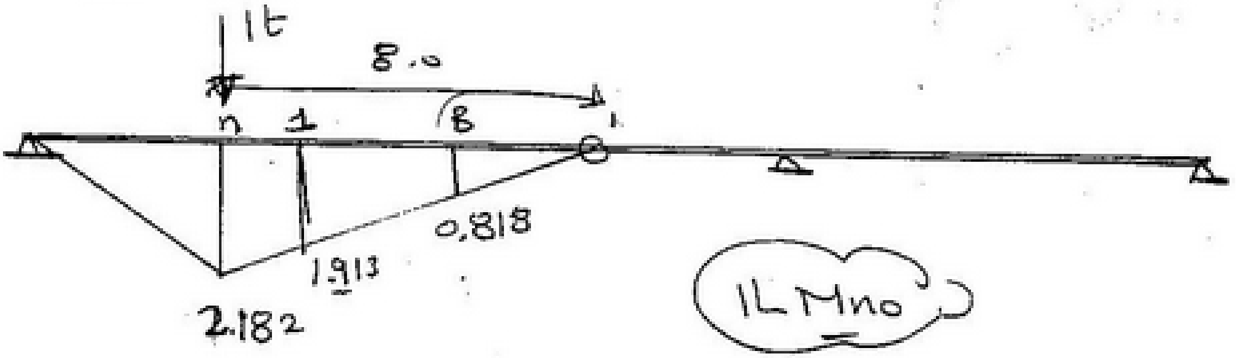
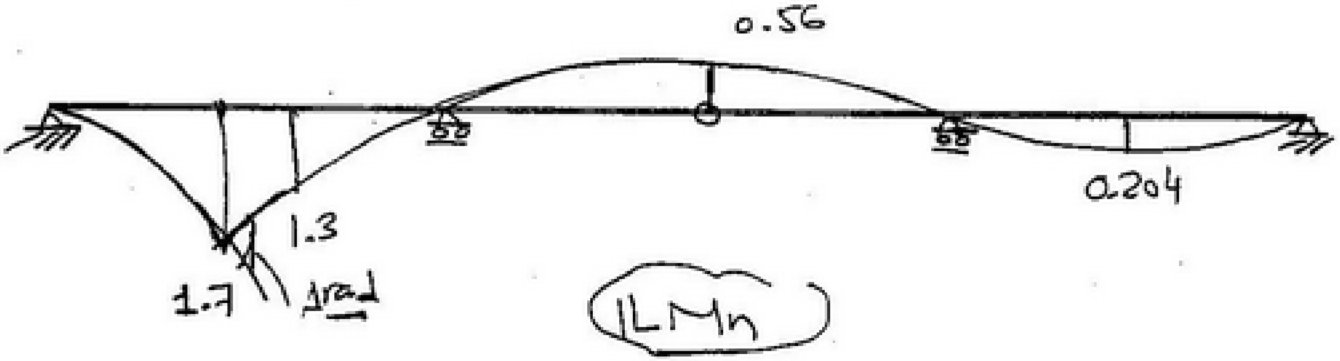
ILMn



$$ILM_n = ILM_{no} - 0.818 \times ILy_B$$



ILQn   <u>Load</u> A → n

$$ILQ_n = -(ILy_B + ILy_c + ILy_d)$$

$$= ILy_A - 1$$

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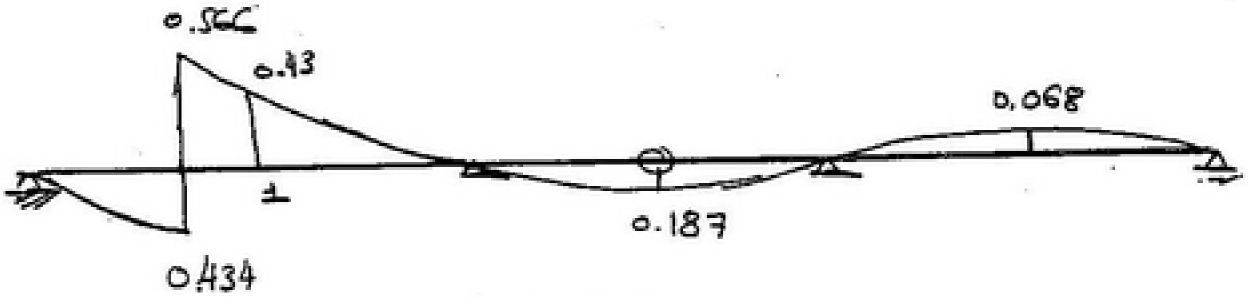
Load n → d

$IL Q_n = IL y_A$



$(IL Q_n)$

$IL Q_{BL}$

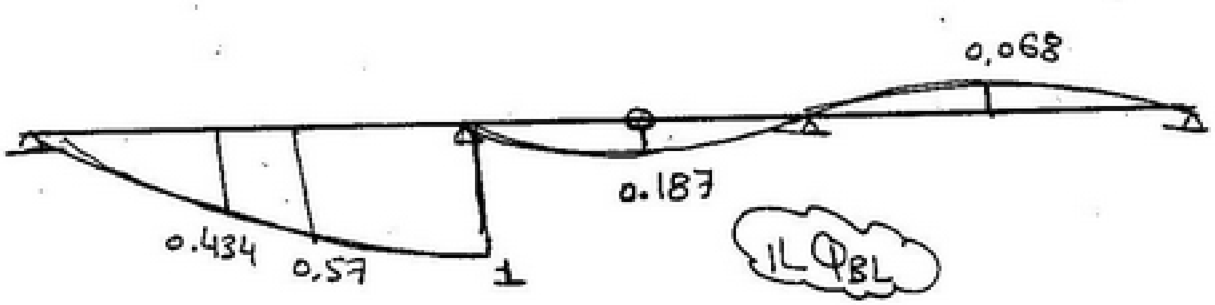
Load B_L → d.

$IL Q_{BL} = IL y_A$

Load A → B_L

$IL Q_{BL} = -(IL y_B + IL y_C + IL y_d)$

$= IL y_A - 1$



$IL Q_{BL}$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

IL Q_{Br}

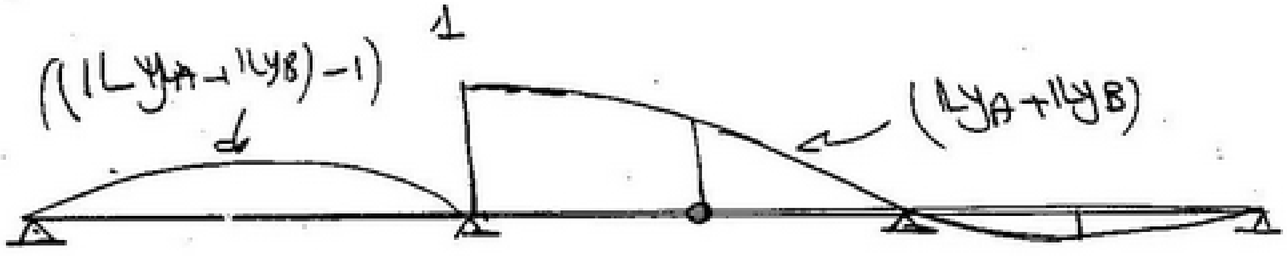
Load A → Br

$$IL\,Q_{Br} = -(IL\,y_c + IL\,y_d)$$

$$= (IL\,y_A + IL\,y_B) - 1$$

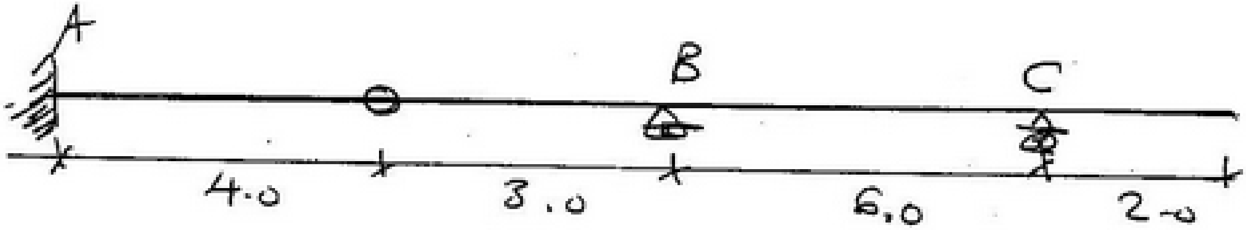
Load Br → d

$$IL\,Q_{Br} = IL\,y_A + y_B$$



IL Q_{Br}

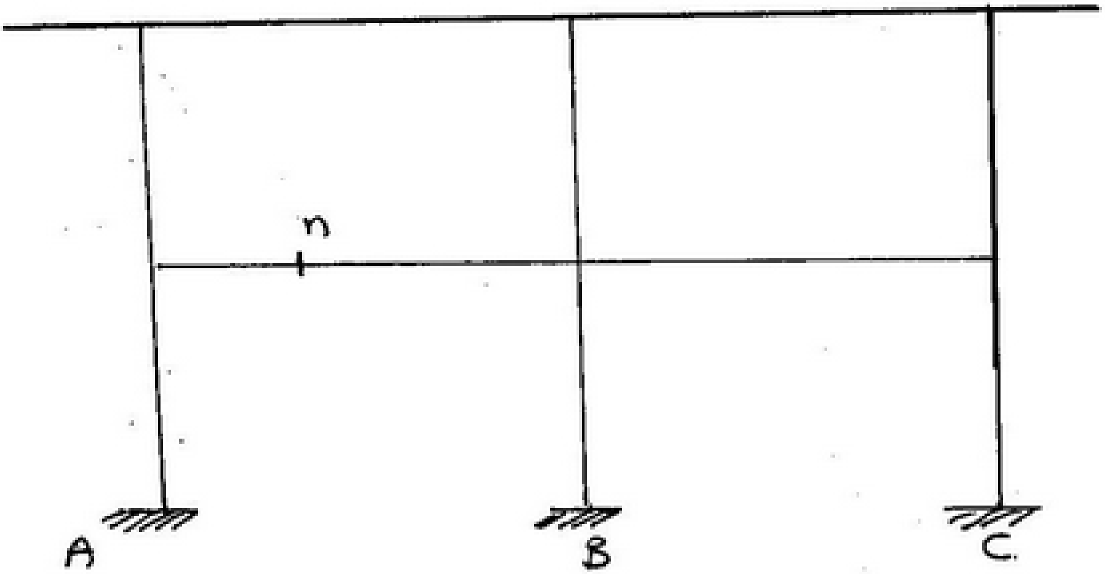
H.W

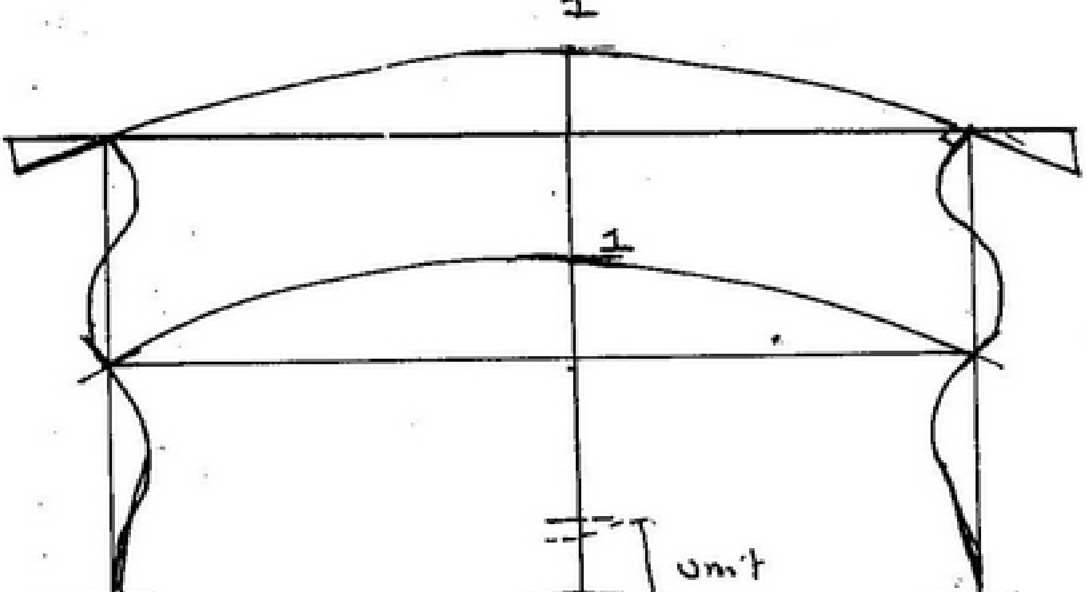


مطلوب ارسم خطوط التأثير

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

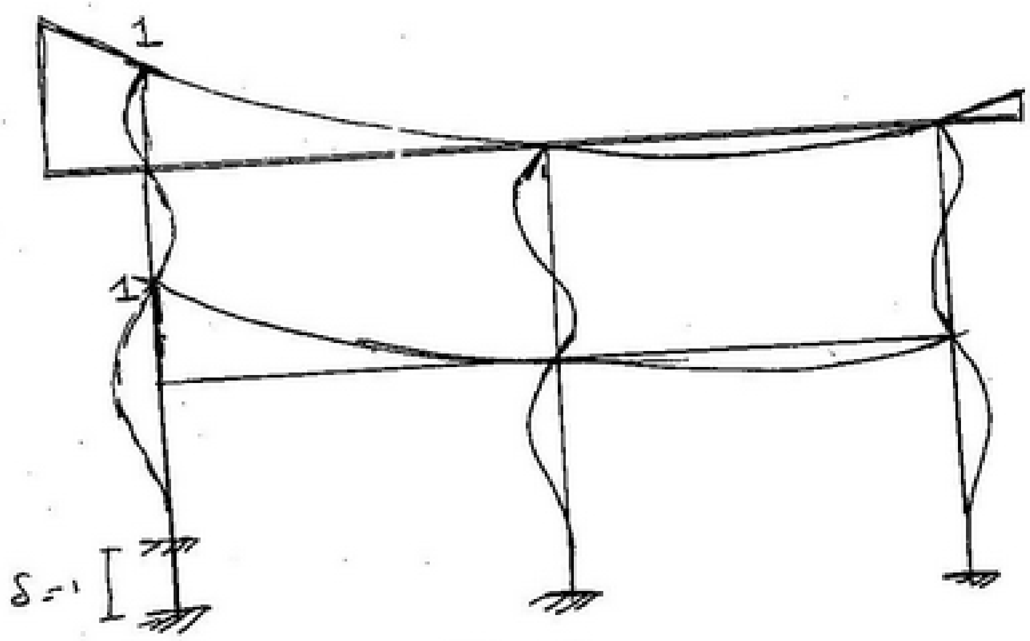
بسم الله الرحمن الرحيم



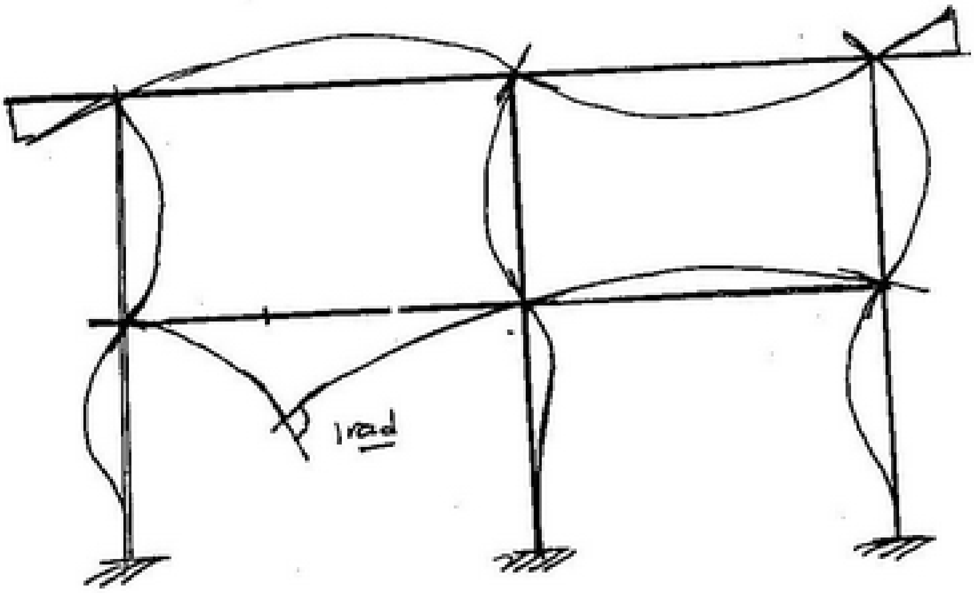


$(IL\underline{y}_B)$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

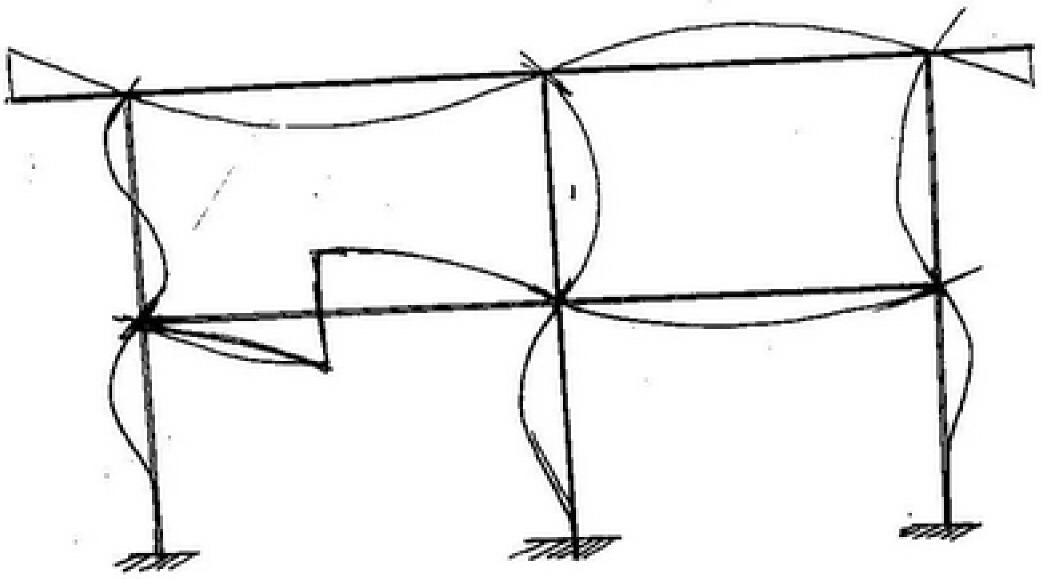


ILYA

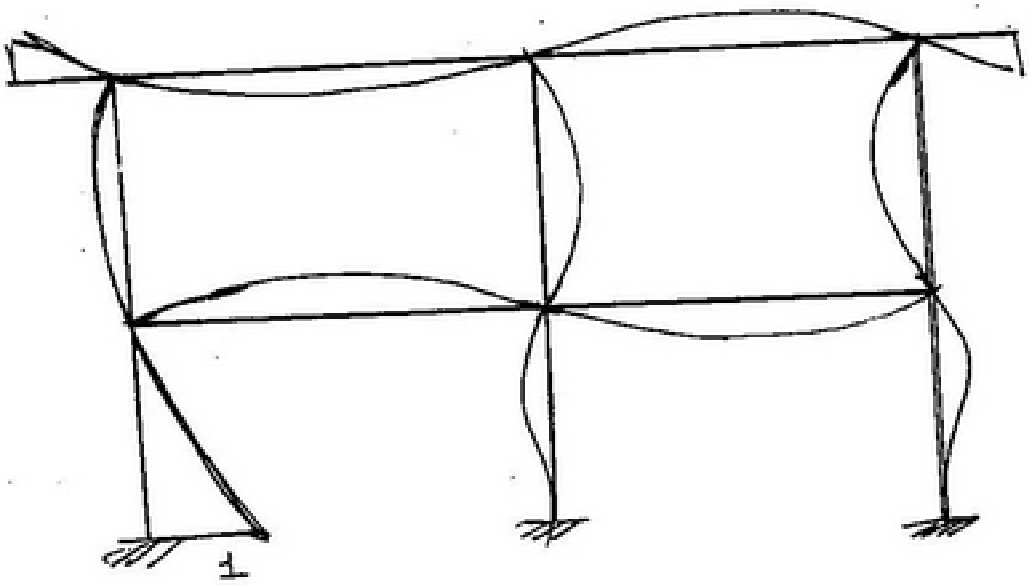


(ILMn)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

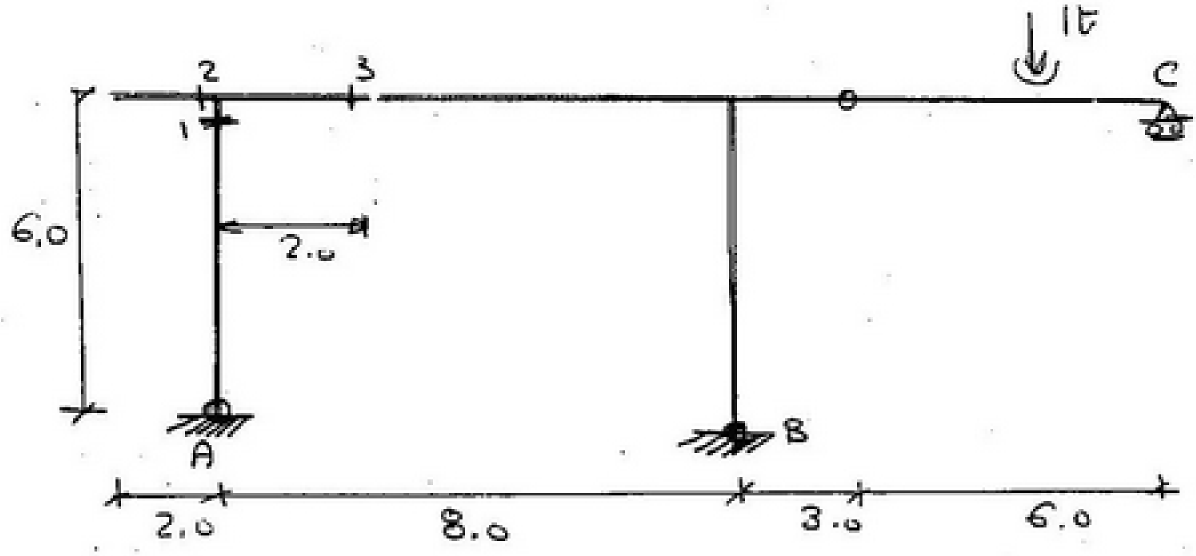


(ILQn)



(ILXA)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

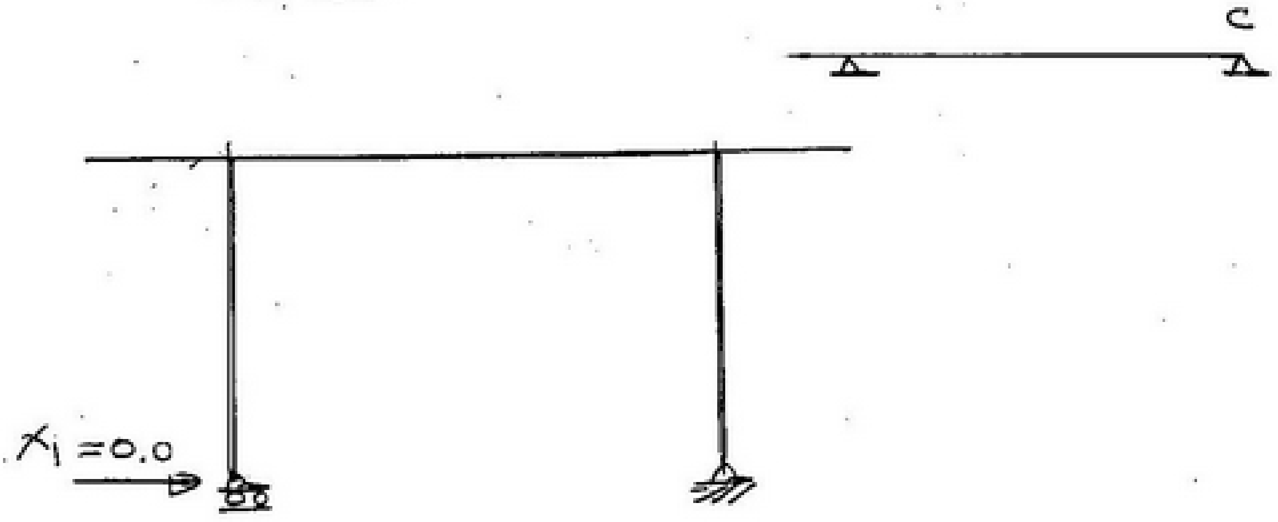


Req IL y_A, y_B, X_A, X_B, IL y_C, IL N_1, IL Q_1, IL M_1

IL Q_2, M_2, N_2, IL N_3, Q_3, M_3

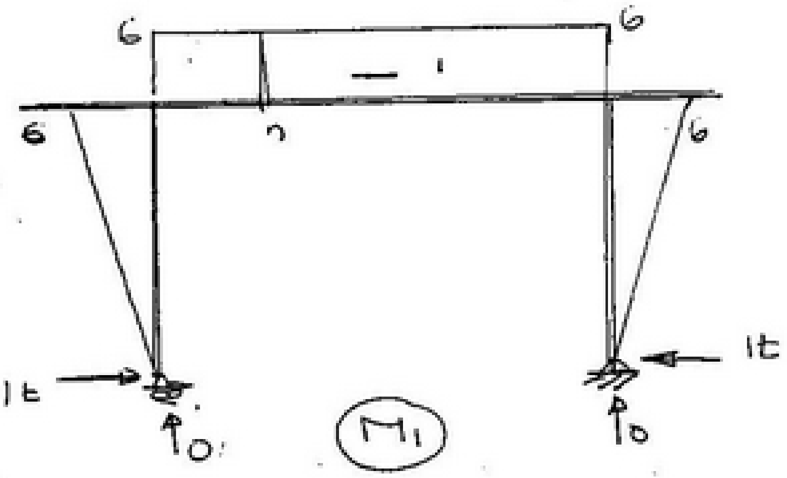
Sol^n

main system



ضع $=X_1$ ① بالرسم العام

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com



$$\delta_{11} = \int \frac{M_1^2}{EJ}\, dL$$

$$= \frac{1}{EJ}\left(\frac{6^2 * 6}{3} * 2 + 6^2 * 8\right)$$

$$\frac{432}{EJ}$$

نقسم δ_{11} على δ_B شئ

وبما انه تم حساب def عند نقاط معينه (مختاره)

ونقسم كل δ ع

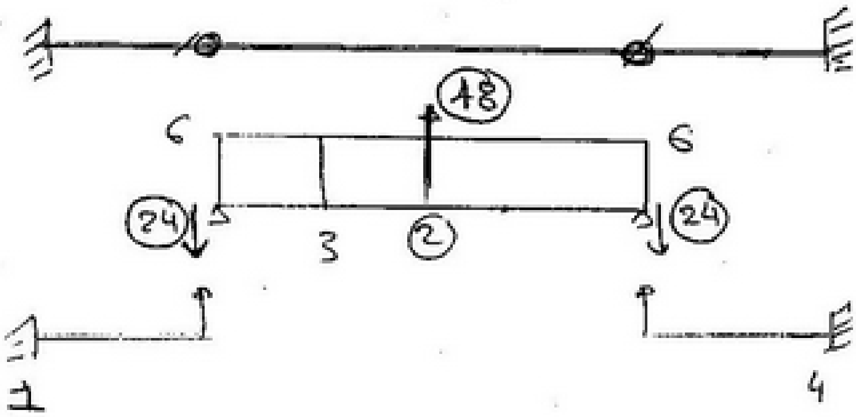
للحصول ع (δ_{11})

$$(ILX) = (ILX_A = ILX_B)$$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

١ ـ شيلت الدعامة بمكانها .

Conj

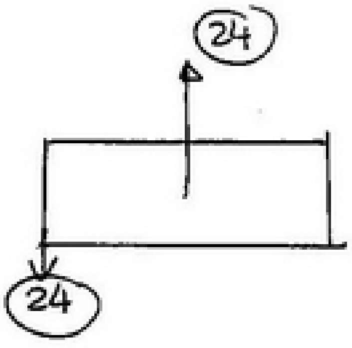


$\delta_1 = 24 * 2 = 48$

$\delta_2 = -48$

$\delta_3 = -36$

$\delta_4 = 24 * 3 = 72$



قسم كل δ على (δ_{11})

Applying Muller

$\delta_{11} x_1 = 1$

$x = \frac{1}{\delta_{11}}$

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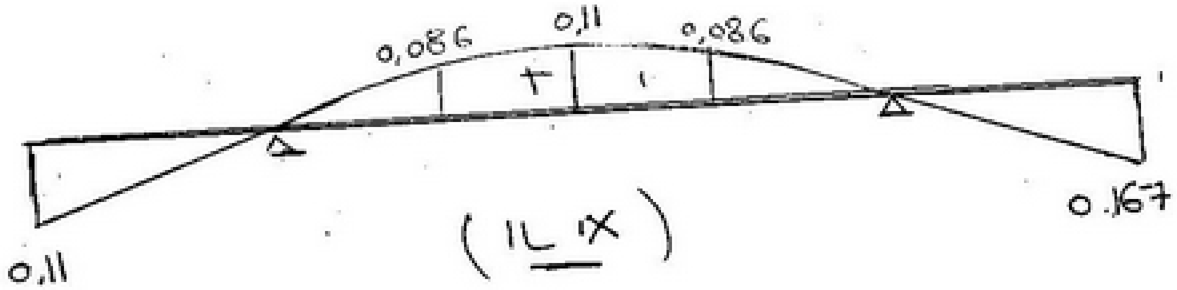
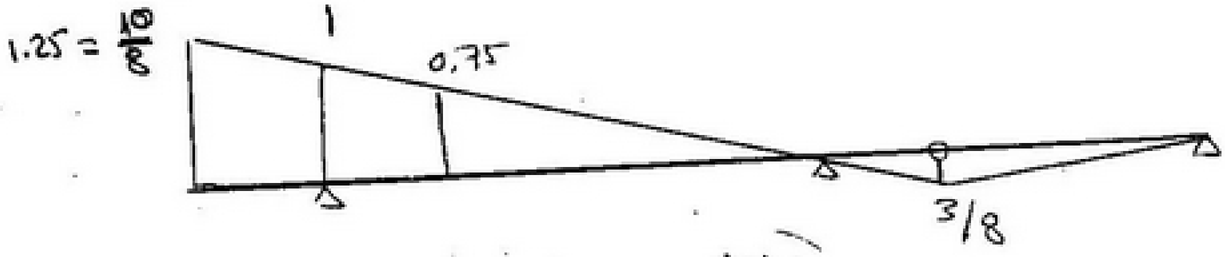


(IL X)

IL y_A

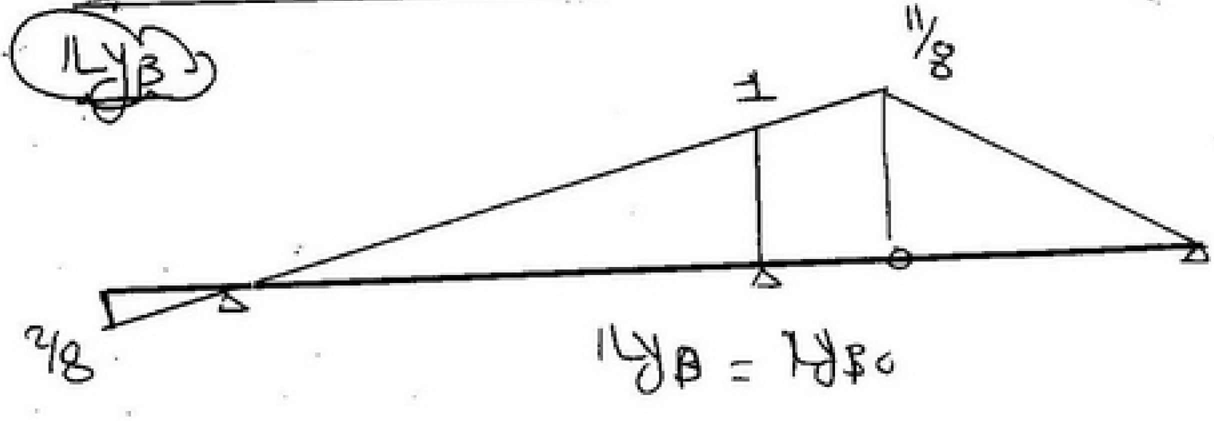
$$IL\,y_A = IL\,y_{A_0} - \left[\begin{matrix} y_A \\ \text{main system} \end{matrix} \right] \times IL\,X$$

$$IL\,y_A = IL\,y_{A_0}$$



$$IL\,y_A = IL\,y_{A_0}$$

IL y_B

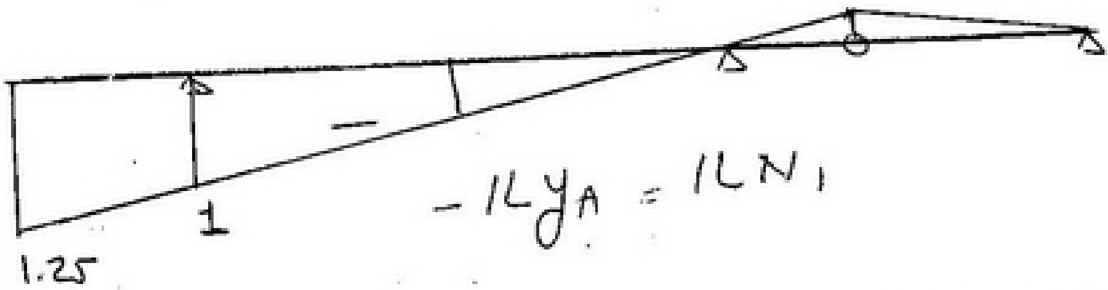


$$IL\,y_B = IL\,y_{B_0}$$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

IL N_1

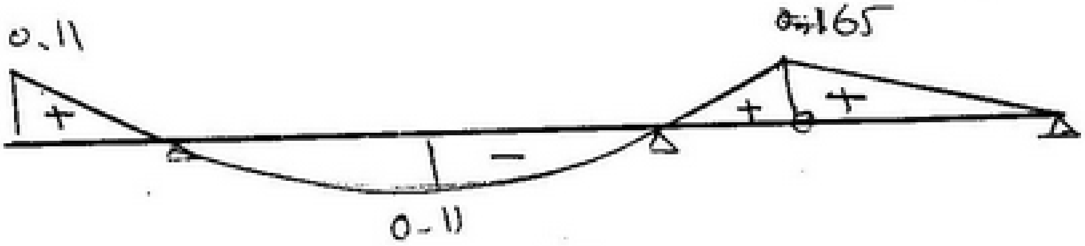
$IL\ N_1 = -IL\ y_A$ ضغط



$-IL\ y_A = IL\ N_1$

IL Q_1

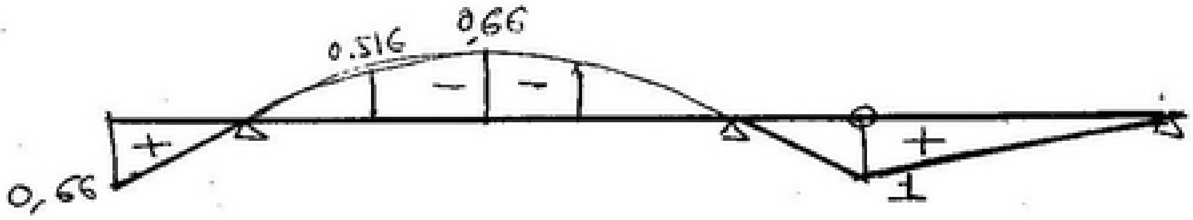
$IL\ Q_1 = -IL\ X$ شغال ونازل



(IL Q_1

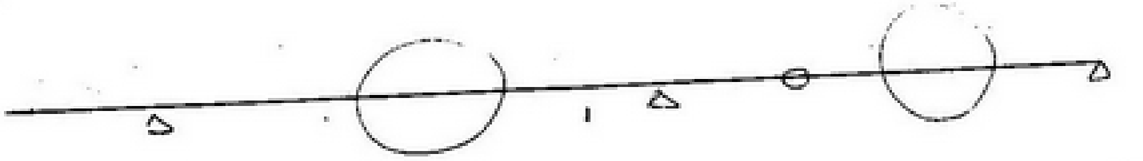
IL M_1

$IL\ M_1 = -(IL\ x) * 6$

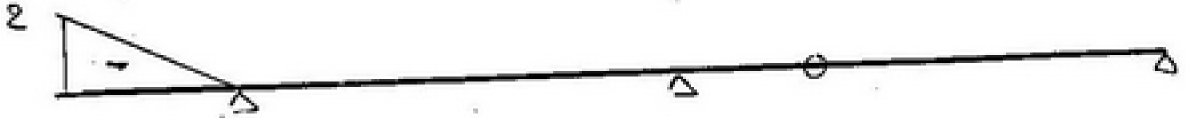


scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

IL N_2 = zero



IL M_2



IL Q_2

Load 2 → C

IL Q_2 = zero

load first → 2

IL Q_2 = 1t

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

IL N_3

$IL\ N_3 = -IL\ x$

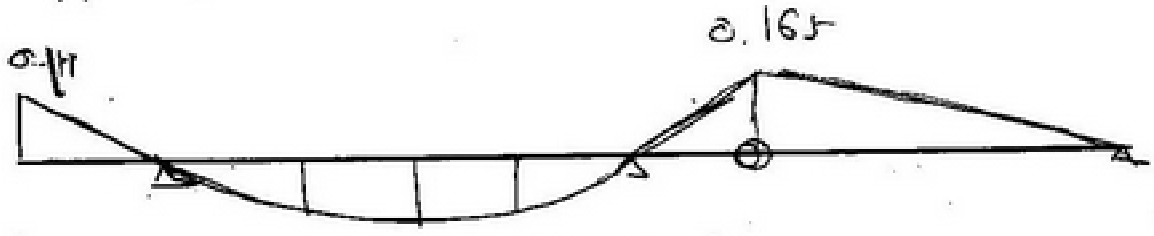
IL Q_3

load first to -3

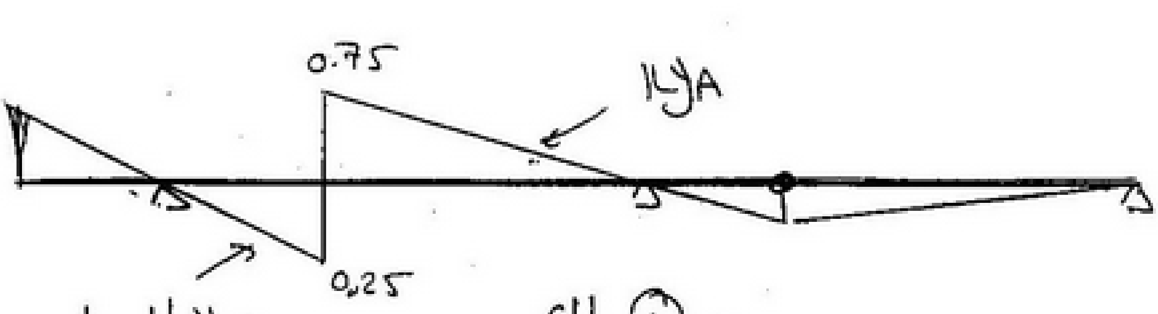
$IL\ Q_3 = -(ILy_B + ILy_C)$

load 3 $\longrightarrow$ C

$IL\ Q_3 = ILy_A$



(IL N_3)



(IL Q_B)

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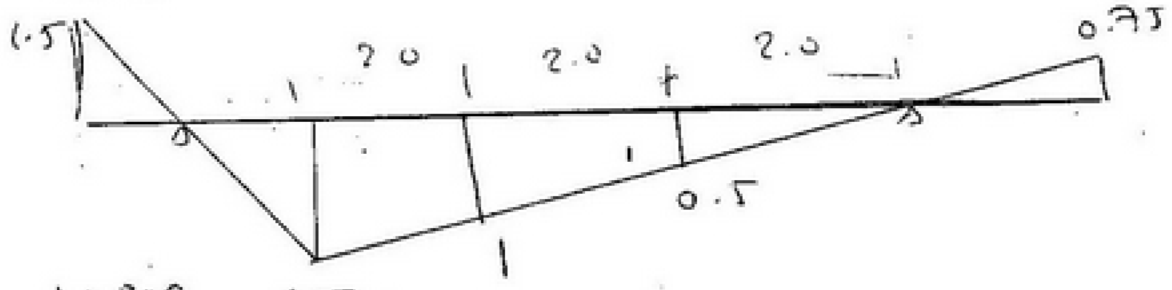
titanic_ship1912@yahoo.com

IL M_3

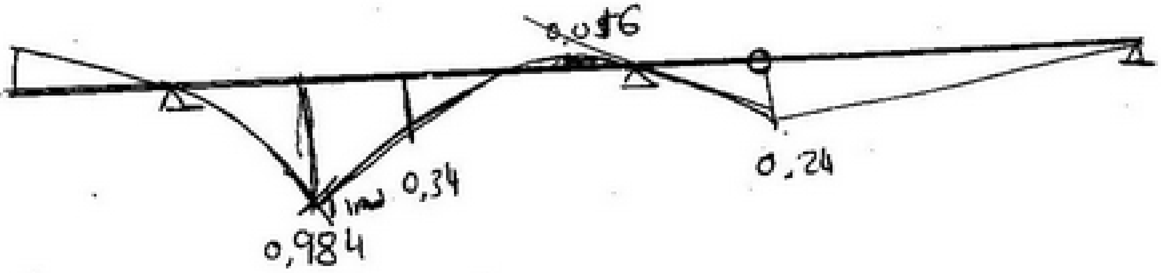


$$1 * \frac{2*6}{8} = 1.5$$

IL$(M_3)_0$

$$IL\,M_3 = IL(M_3)_0 - \sigma_p * (IL\,X)$$

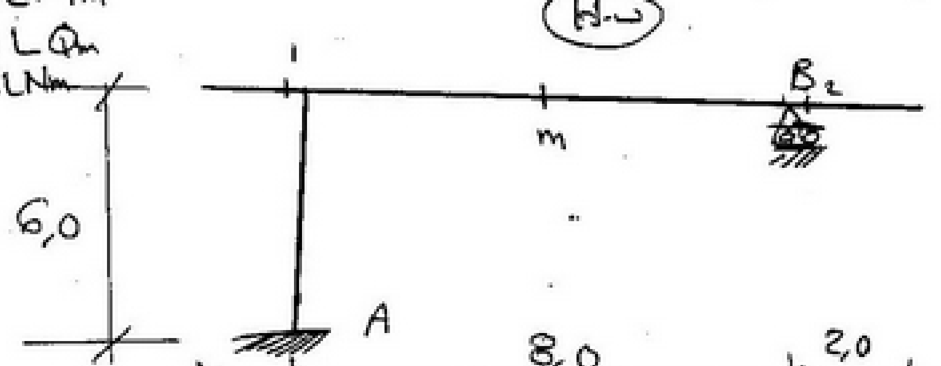
القيمة خاصة بال N في ال main system



(IL M_3)

IL X_A
IL y_A
IL y_B
IL M_A
IL M_1
IL Q_1
IL M_2
IL Q_2

IL M_m
IL Q_m
IL N_m



scanner by : mahmoud ashraf
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STRUCTURE MECHANICS

2 nd Year

CIVIL

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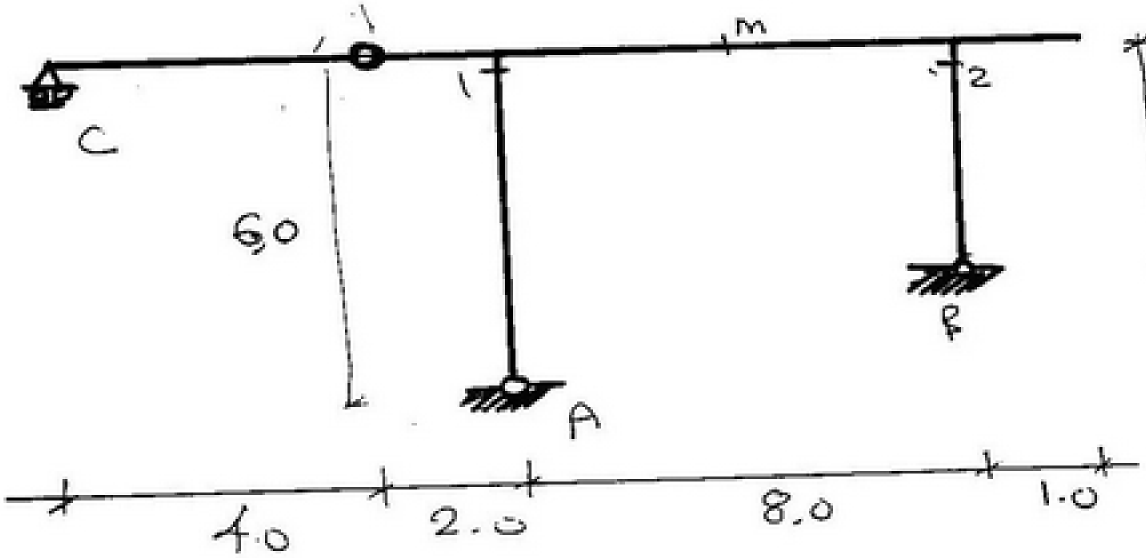
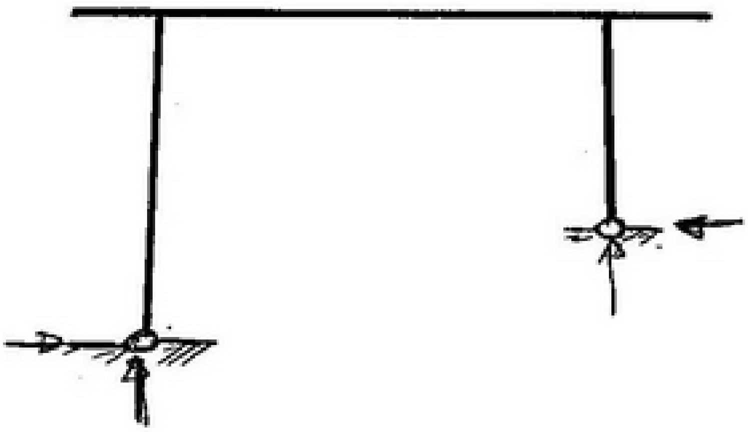
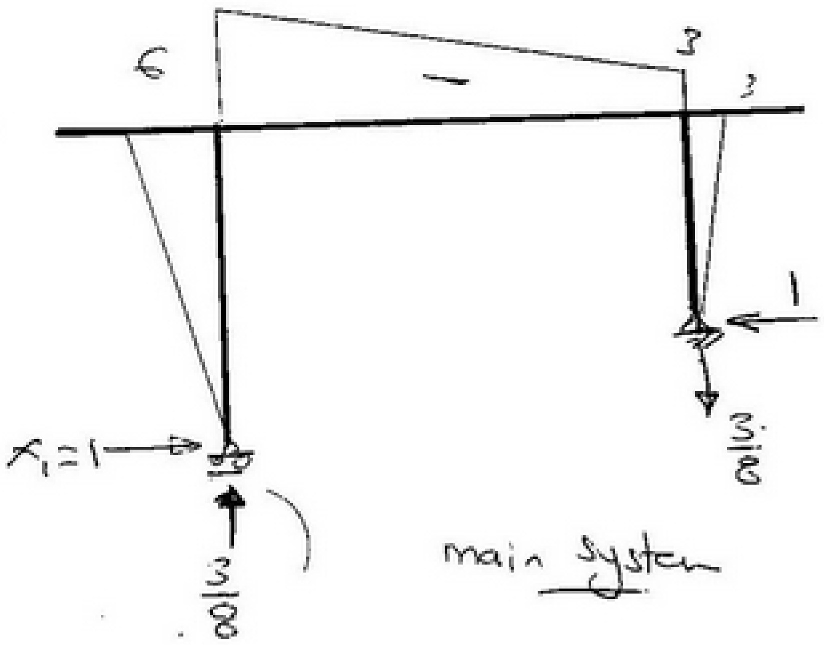
titanic_ship1912@yahoo.com

بسم الله الرحمن الرحيم





scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com



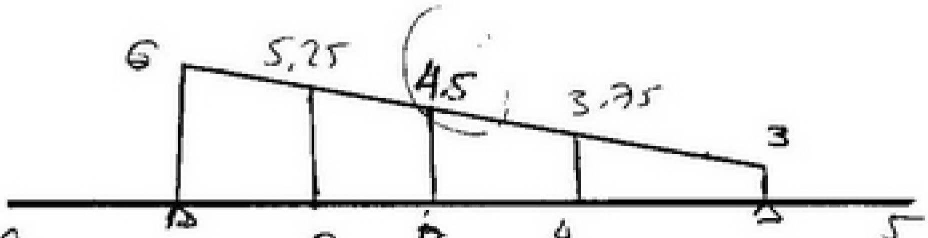
main system

(M_1)

$$\delta_{11} = \int \frac{M_1^2}{EI} \, dL$$

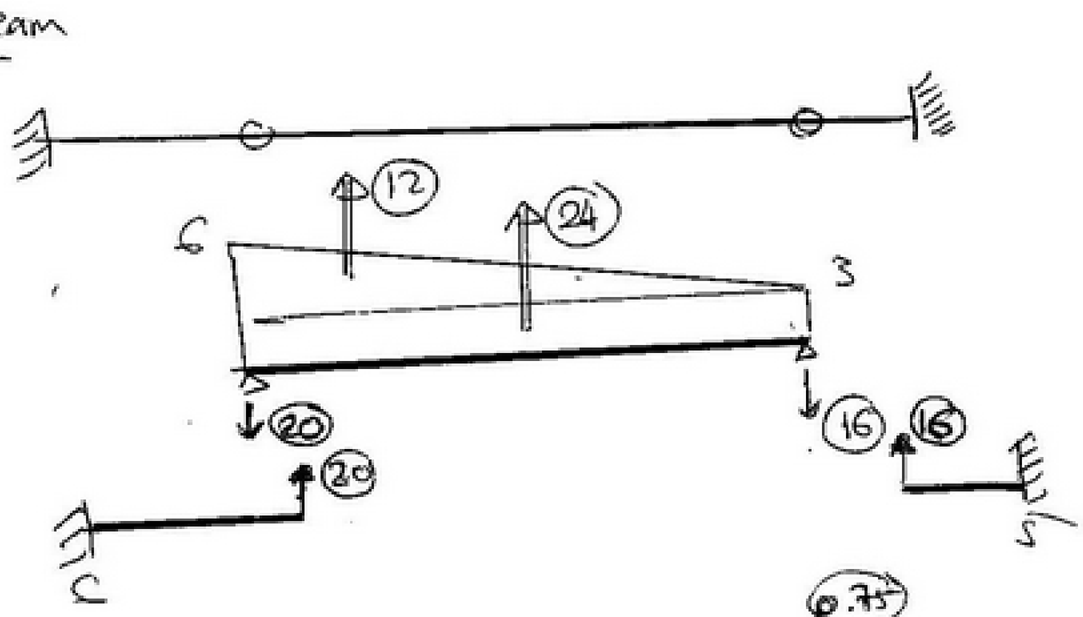
$$= \frac{6^2 \times 6}{3} + \frac{3^2 \times 3}{3} + \frac{8}{3}\left(6^2 + 3^2 + 3 \times 6\right)$$

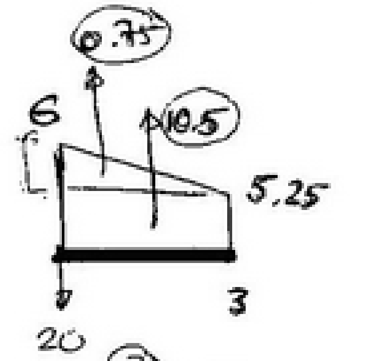
$$= \frac{249}{EI}$$



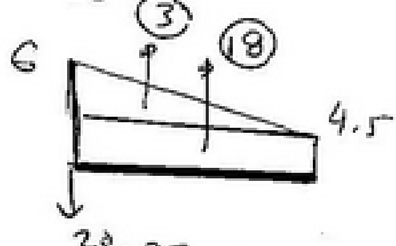
scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Conj beam

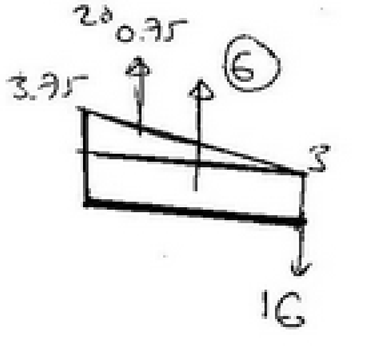




$$\delta_3 = -20*2 + 10.5*1 + 0.75 \times 1.33$$
$$= -28.5/EI$$



$$\delta_m = -20*4 + 18*2 + 3 \times 2.67$$
$$= -36/EI$$



$$\delta_4 = -16*2 + 6*1 + 0.75*0.67$$
$$= -25.5/EI$$

$$\delta_5 = 16*1 = 16/EI$$

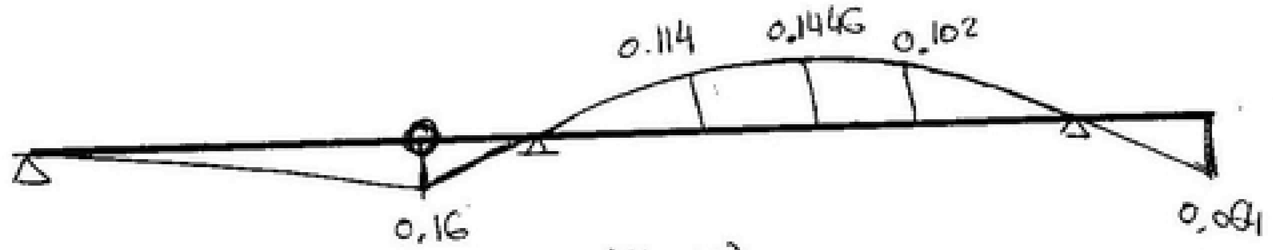
$$\delta_6 = 20*2 = 40/EI$$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Apply Muller Bresaulu

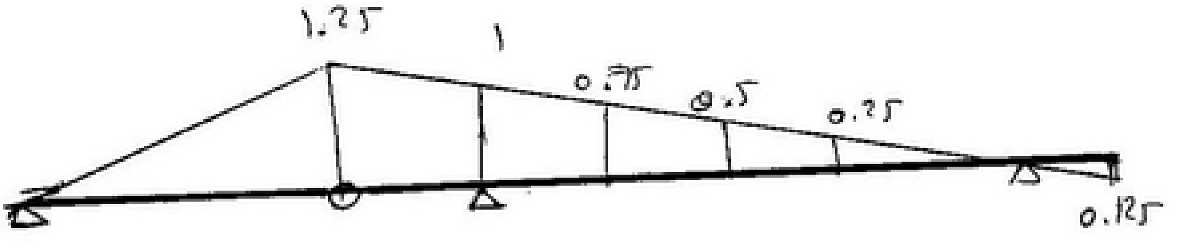
$$\delta_{11} x_1 = 1$$

$$x_1 = \frac{1}{\delta_{11}}$$



(IL X)

IL y_A

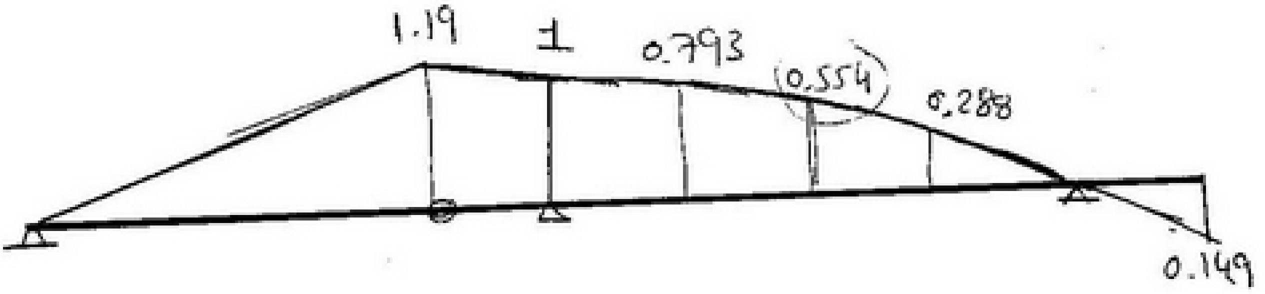


(IL y_{A_0})

$$IL\,y_A = IL\,y_{A_0} + (\text{value}) \times IL\,X$$

$$= IL\,y_{A_0} + \frac{3}{8}\,(IL\,X)$$

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com



(ILy_A)

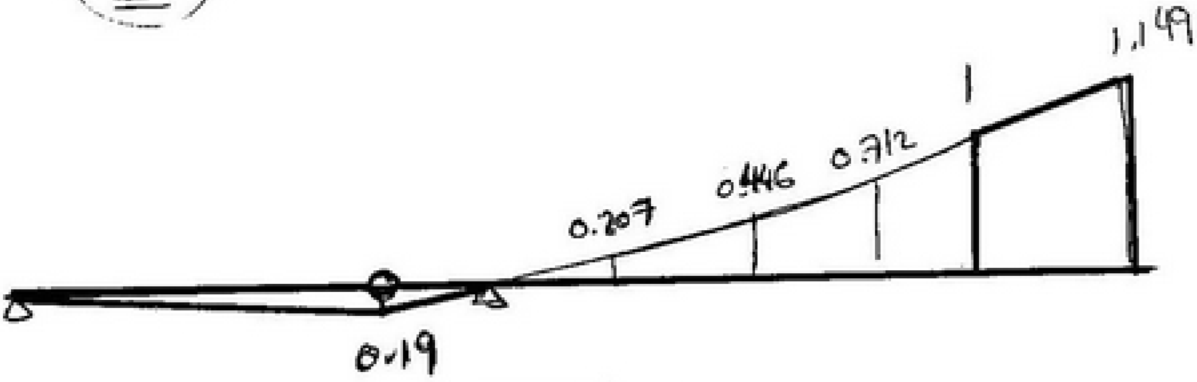
1 - 1.19

لاحظ أن القيمة في المنتصف أكبر من (0.5) لذا سيكون المنحنى مقوس للأعلى

ILy_B

$$IL y_B = \left(IL y_{B0} - \frac{3}{8} IL X \right)$$

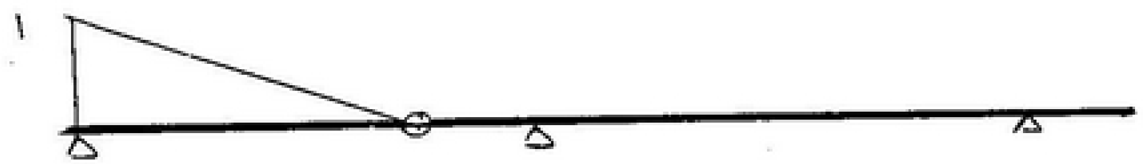
(or) $IL y_B = 1 - IL y_A$



(ILy_B)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

ILy_c

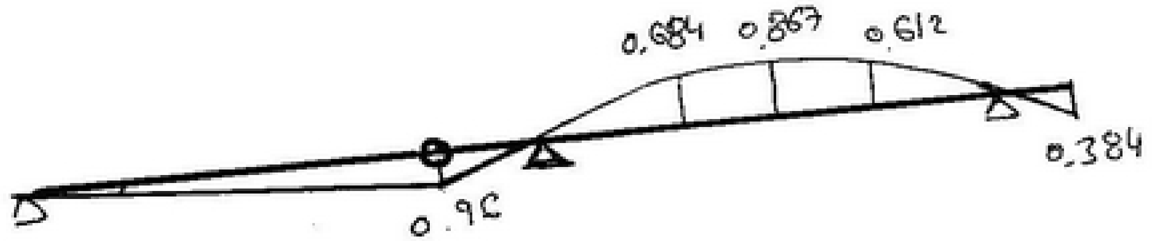


ILM_1

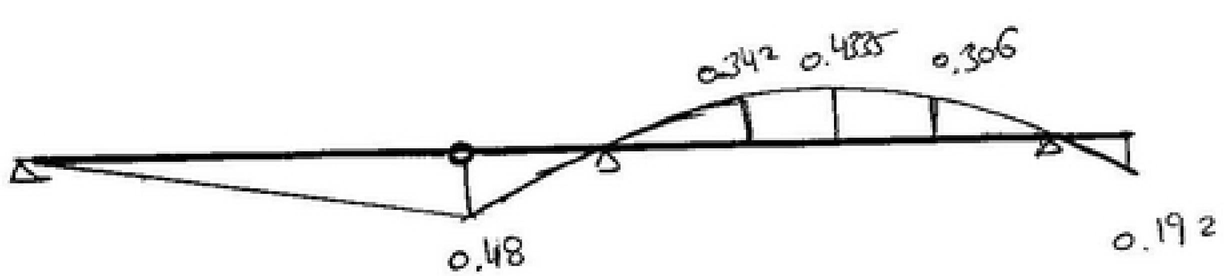
$IL M_1 = IL x * 6$

ILM_2

$IL M_2 = IL x * 3$



(ILM_1)



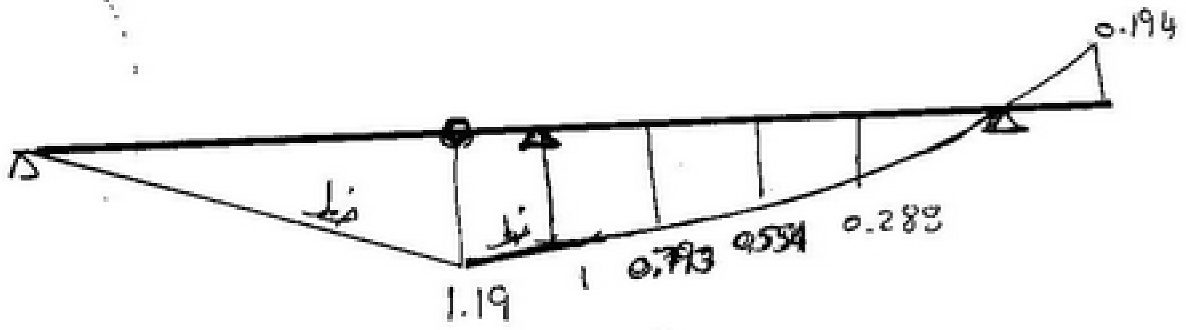
(ILM_2)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

$IL\,N_1 = -IL\,y_A$ Comp

$IL\,N_2 = -IL\,y_B$ Comp

$IL\,N_m = -IL\,x$ Comp

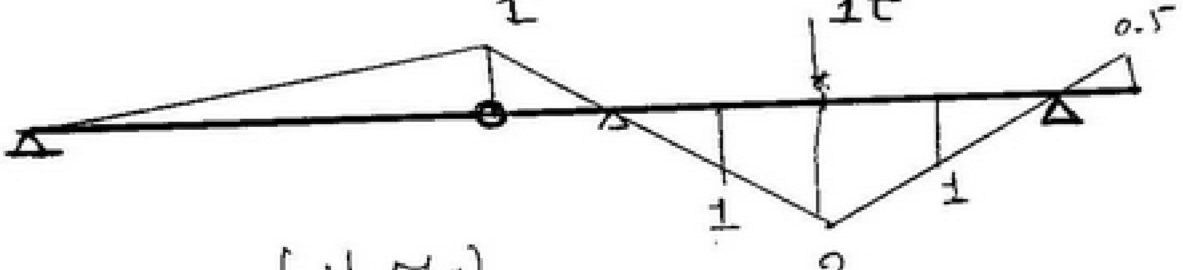


(IL N_1)

IL Mm

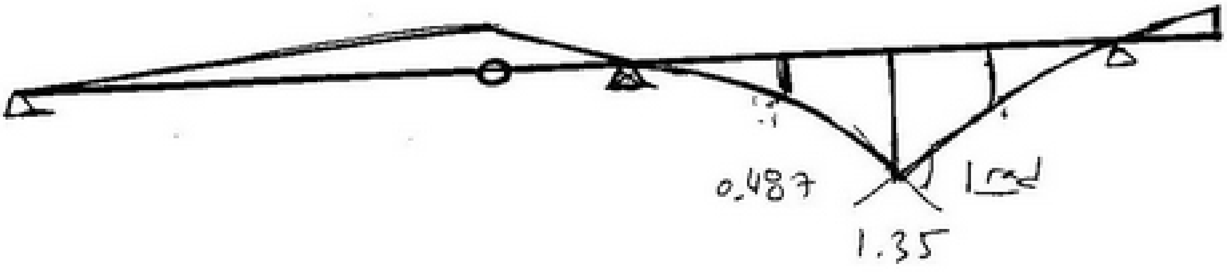
$IL\,M_m = IL\,M_o + \text{Value} * IL\,X$

$= IL\,M_o - 4.5\ IL\,X$



(IL M_o)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com



(IL Mm)

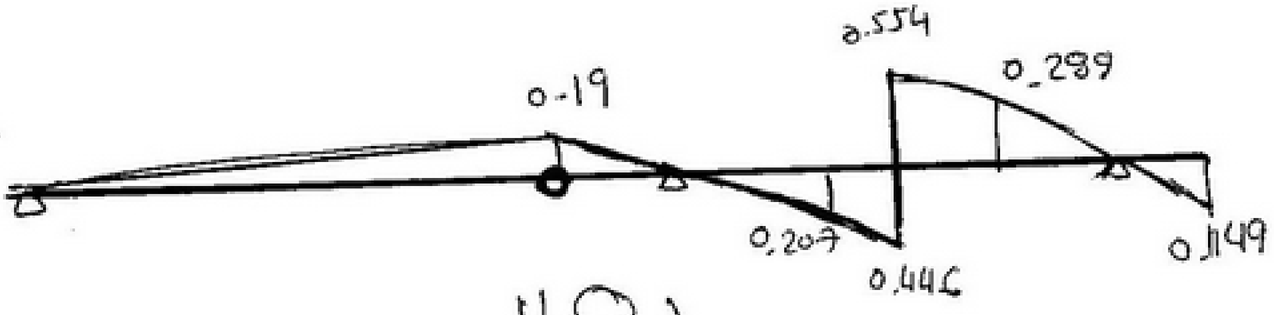
IL Q_m

Load C → M

$$IL Q_m = -IL y_B$$

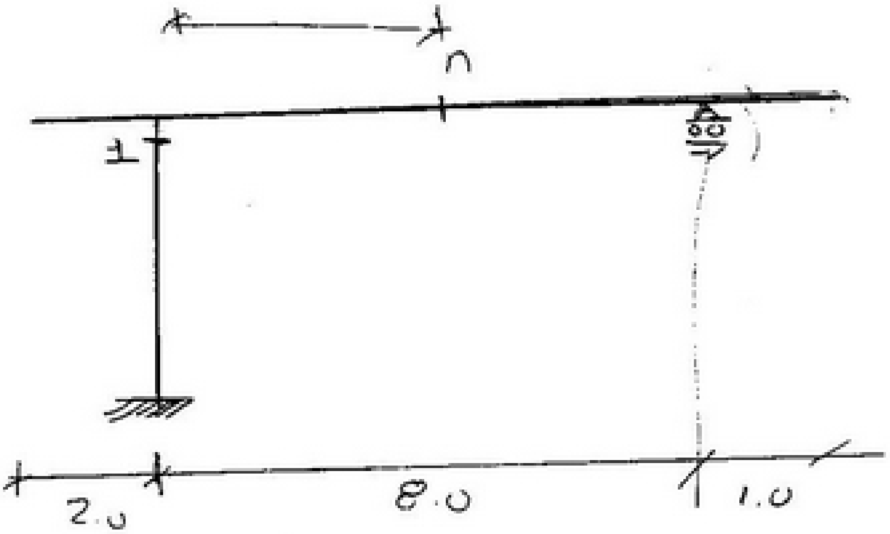
Load M → B

$$IL Q_m = +IL y_A + IL y_C$$



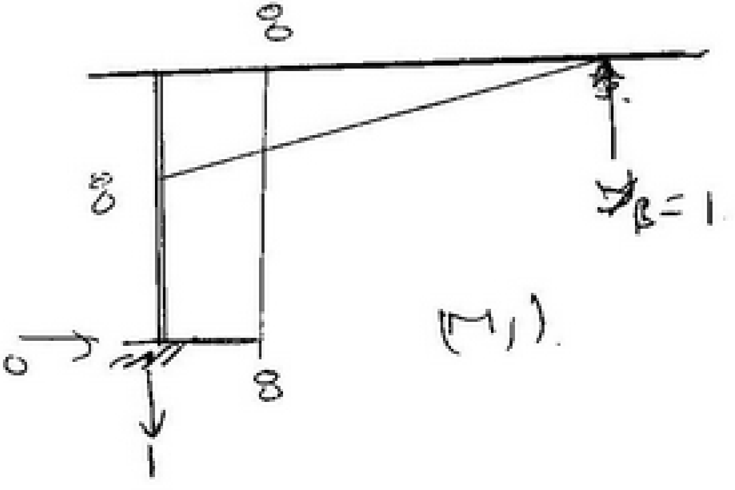
(IL Q_m)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com



req $IL\ y_A, y_B, M_A, \underline{X_A}, M_1, Q_1, N_1$

M_n, Q_n, N_n.



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titanic_ship1912@yahoo.com

17

STRUCTURE MECHANICS

2 nd Year

CIVIL

CH: INFLUENCE LINES

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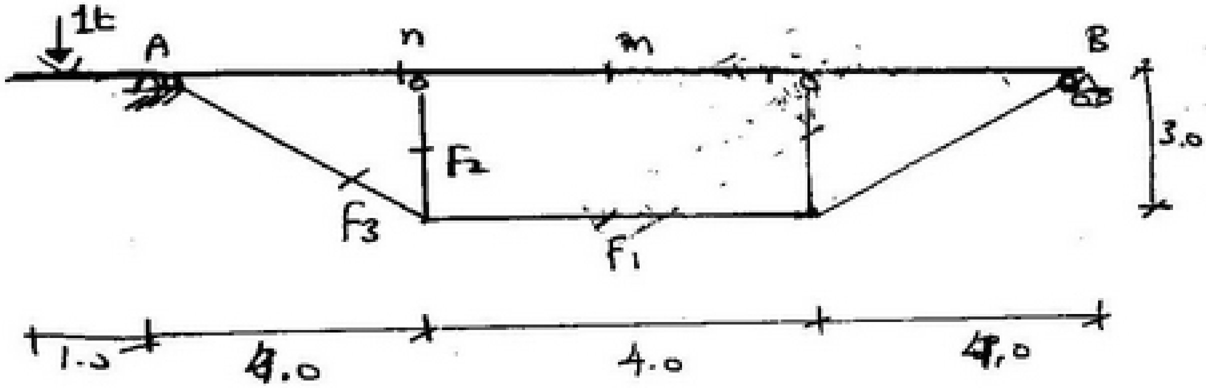
titanic_ship1912@yahoo.com

سكشن رقم ١٢

Influence Line (Beam _ Truss)



$EA_{Truss} = 10^4\ t$, $EI = 10^4\ t.m^2$, $EA_{beam} = 10^4$

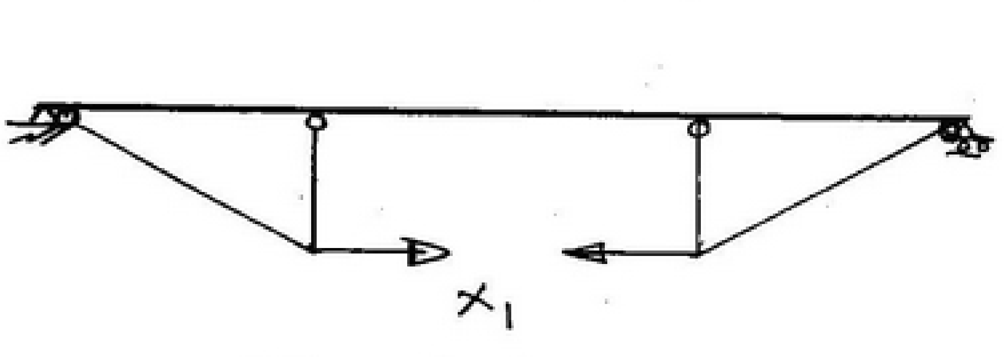
Req IL Y_A, Y_B, IL F_1, F_2, F_3, N_n, Q_n, M_n.

IL M_m, Q_m, N_m

Sol^{n}

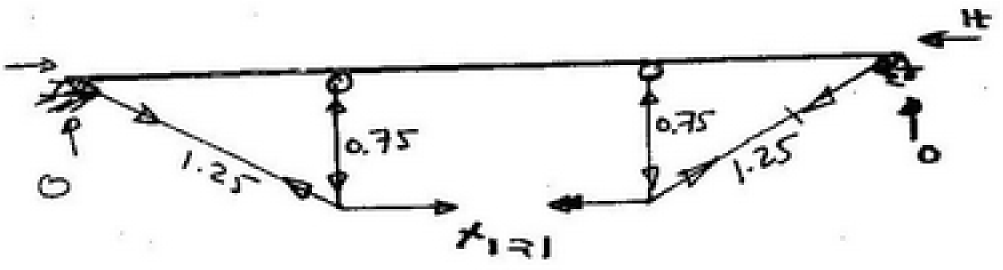
نلاحظ أن المنشأ خارجياً محددة استاتيكياً

داخلياً غير محددة من الدرجة الأولى



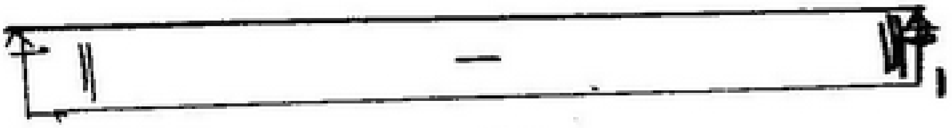
(main system)

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

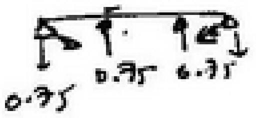


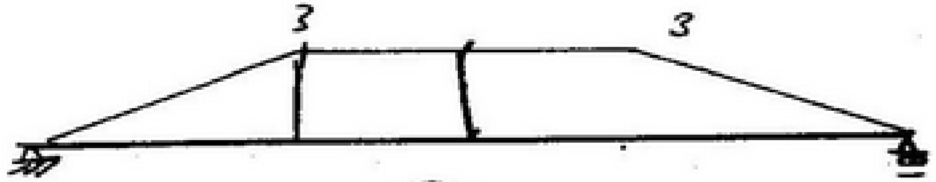
F_1

معطى I و EA بتاع الـ Beam لذا لازم نرسم الـ Normal force



N_1





M_1

$$\delta_{11} = \int \frac{M_1^2}{EI} dL + \int \frac{N_1^2}{EA} dL + \Sigma f_1^2 L/EA$$

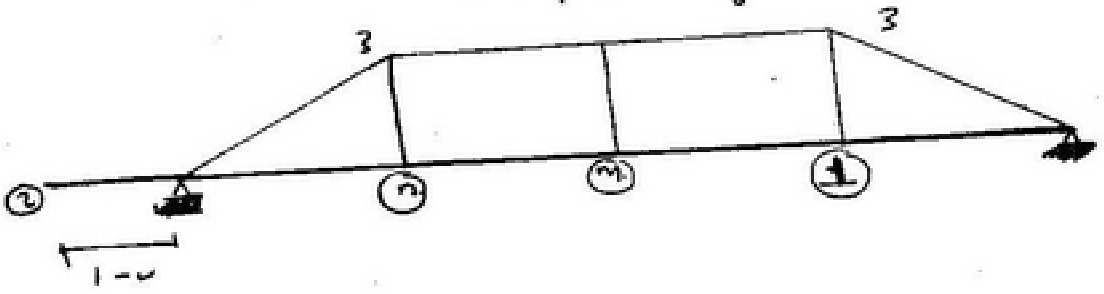
$$= \frac{1}{EI_{beam}} \left(\frac{3^2 * 4}{3} * 2 + 3^2 * 4 \right) + \frac{1}{EA_{beam}} \left(1^2 * 12 \right) +$$

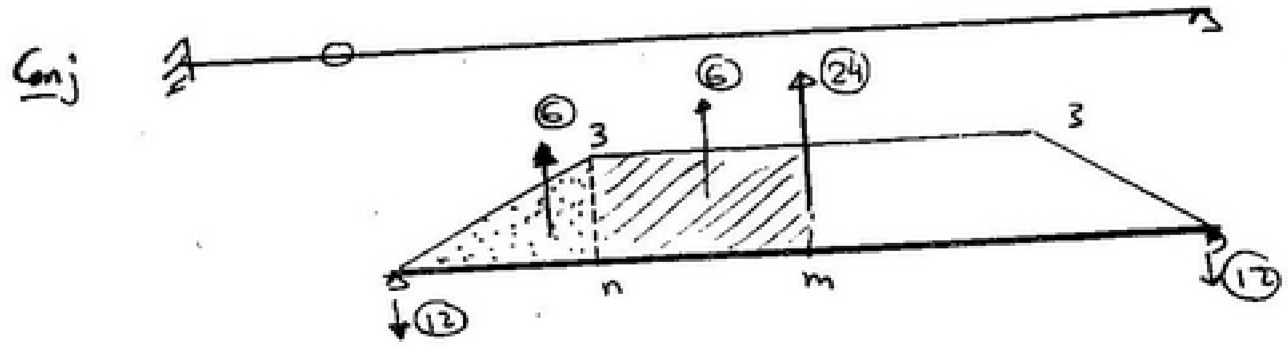
$$\frac{1}{EA_{truss}} \left(1.25^2 * 5 * 2 + 0.75^2 * 3 * 2 + 1^2 * 4 \right)$$

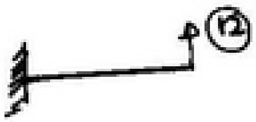
scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

$\delta_{11} = 95/EJ = 95/10^4$

ثم حساب ال def عند النقاط







$\delta_2 = 12 * 1 = 12$

$\delta_n = -12 * 4 + 6 * 4/3 = -40$

$\delta_m = -12 * 6 + 6 * 3.33 + 6 * 1$
$= -46$

ثم قسمة كل ال δ ع (δ_{11})

ونرسم نحصل ع (IL F_1)

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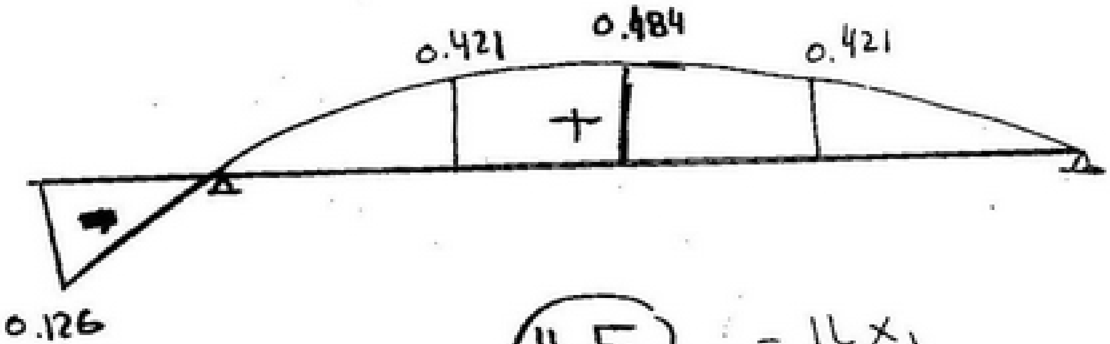
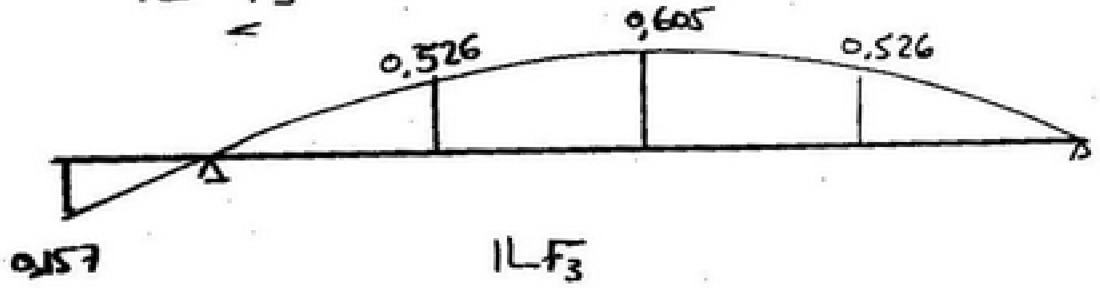


IL F_1 = IL X_1

IL F_3

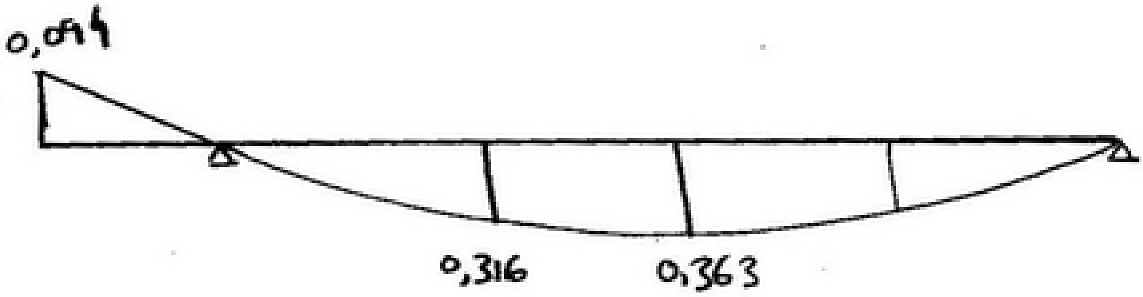
IL F_3 = 1.25 IL F_1



IL F_3

IL F_2

IL F_2 = − 0.75 IL F_1 (Comp)



IL F_2

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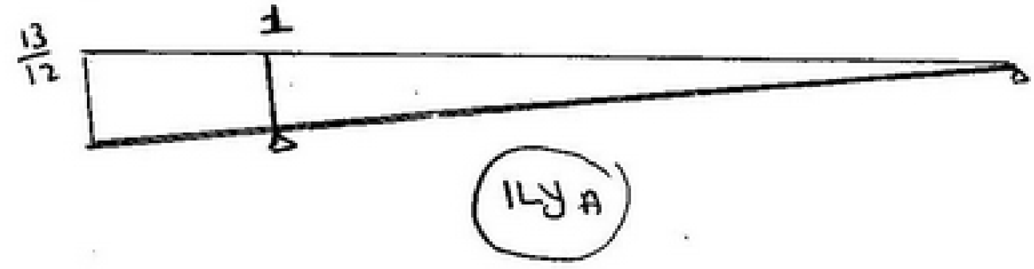
$IL y_A$

$= IL y_{A0} - (\text{value}) \times IL\ X$

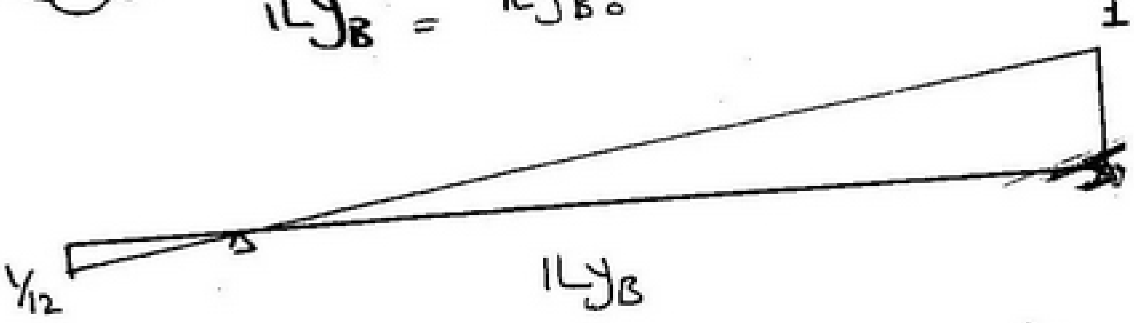
قيمة رد الفعل عند (A) لما نحط $X = 1$ طن

$IL y_A = IL y_{A0}$

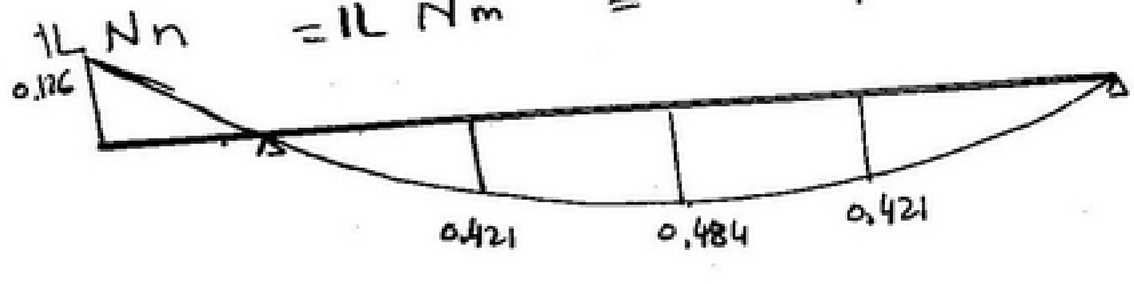


$IL y_B$

$IL y_B = IL y_{B0}$



$IL\ N_n = IL\ N_m = -IL\ F_1$



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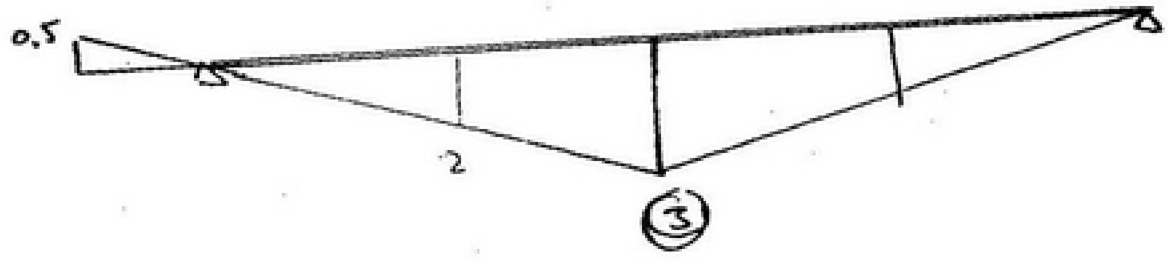
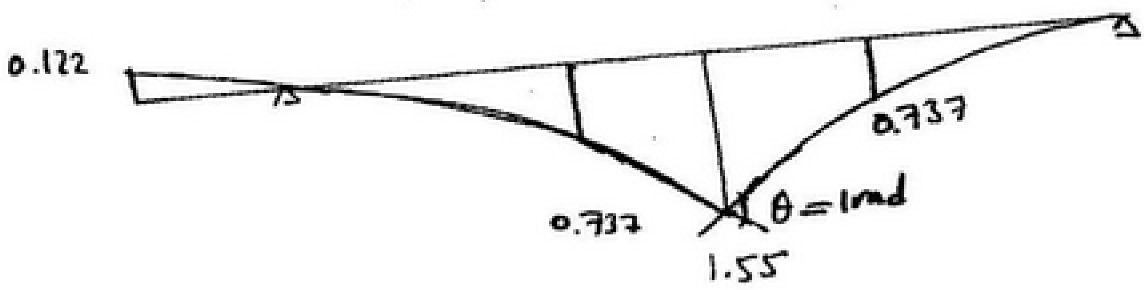
IL Mm



ILMmo

ILF1

ILMm = ILMmo − 3 * (ILX)



ILMm

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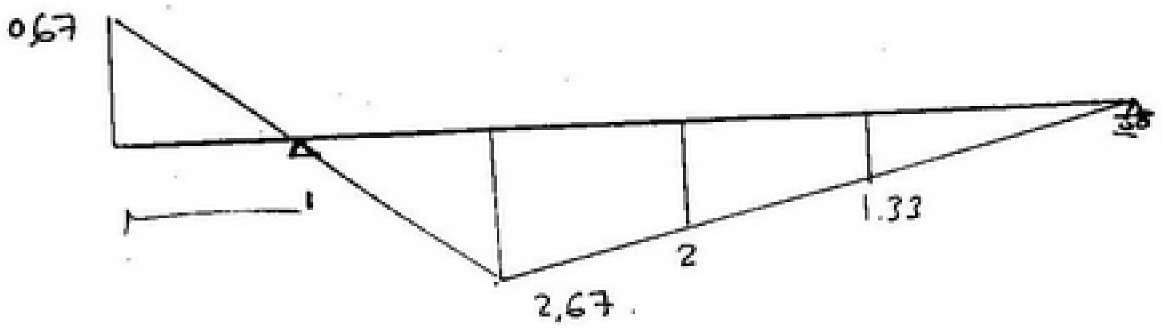
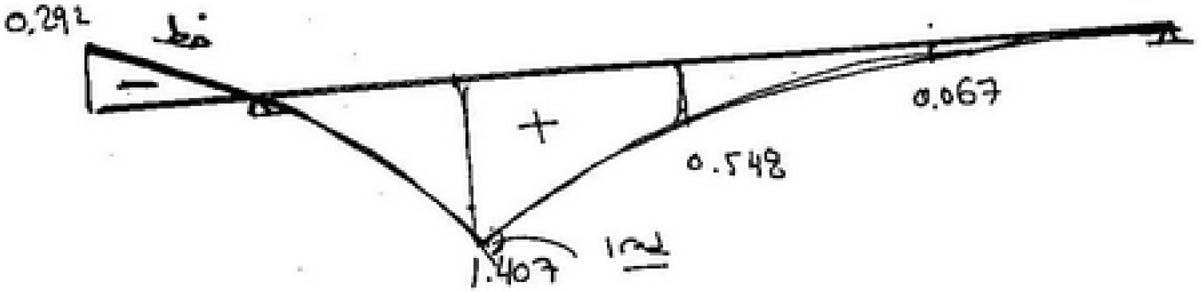
ILMn



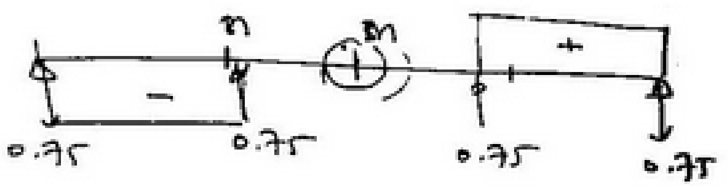
(ILMno)

$$IL\,M_n = IL\,M_{no} - 3 \times IL\,F_1$$



ILM1

ILQm



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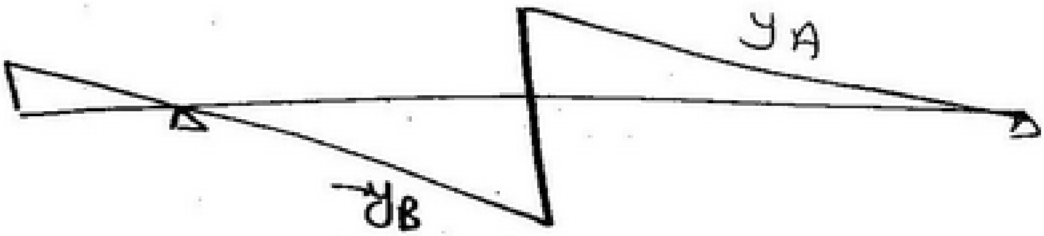
نقطة (m) هكذا نتضح أنه لا تأثير لقوة F_1 عليها من البعض.

$$IL\,Q_m = IL\,Q_{m0}$$



$IL\,Q_m$

$IL\,Q_n$

نتضح من شكل (n) أنه يوجد تأثير على القوة (F_1)

$$IL\,Q_n = IL\,Q_{n0} - 0.75 * IL\,F_1$$

$(IL\,Q_n)$

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18

STRUCTURE MECHANICS

2 nd Year

CIVIL

CH: INFLUENCE LINES

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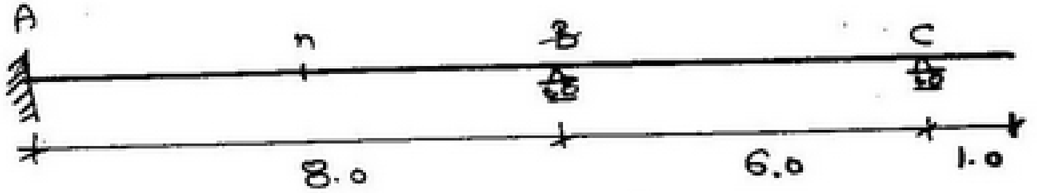
بسم الله الرحمن الرحيم

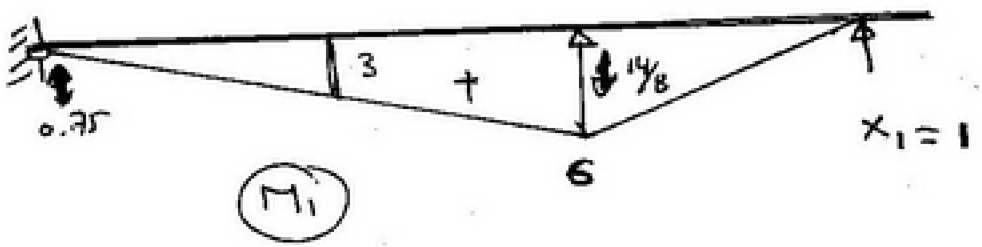


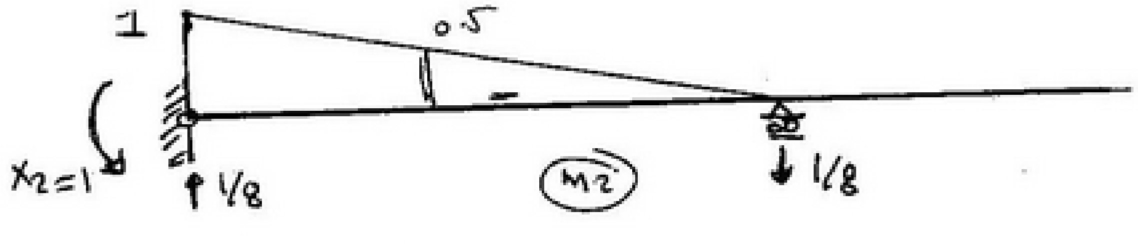
req. IL M_A, IL y_C, IL y_B, IL M_n, IL Q_n

Sol: twice statically indeterminate.

① نجعل المنشأ محدد استاتيكيا

main system





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$$\delta_{11} = \int \frac{M_1^2}{EJ} dL$$

$$= \frac{1}{EJ}\left(\frac{6^2 * 6}{3} + \frac{6^2 * 8}{3}\right) = 168/EJ$$

$$\delta_{22} = \int \frac{M_2^2}{EJ} dL$$

$$= \frac{1}{EJ}\left(\frac{1^2 * 8}{3}\right) = 2.67/EJ$$

$$\delta_{12} = \delta_{21} = \int \frac{M_1 M_2}{EJ} dL$$

$$= \frac{-1 * 6 * 8}{6} = -8/EJ$$

$* \ \delta_{11} x_1 + \delta_{12} x_2 = 1$

$* \ \delta_{21} x_1 + \delta_{22} x_2 = 0$

$168 x_1 - 8 x_2 = EJ \rightarrow (1)$

$-8 x_1 + 2.67 x_2 = 0 \rightarrow (2)$

Solve (1), (2) Get $x_1 = \smile$

$x_2 = \smile$

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$x_1 = 6.94 * 10^{-3}\ EJ \quad , \quad x_2 = 0.0208\ EJ$

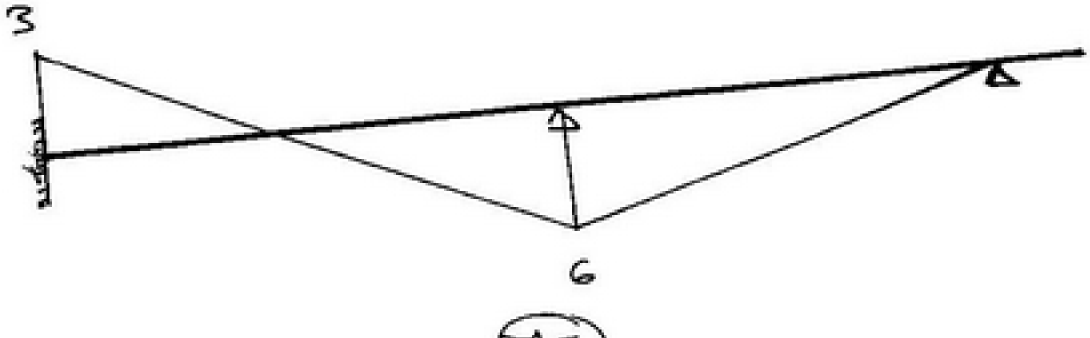
$x_1 = \frac{EJ}{144} \quad , \quad x_2 = \frac{EJ}{48}$

افرض EJ بأي رقم.

$\therefore\ EJ = 144$

$x_1 = 1 \quad , \quad x_2 = 3$

$M_F = x_1 M_1 + x_2 M_2$



(M_F)

حول ال main system إلى Conj beam وحمله بالعزم النهائي

(M_F)

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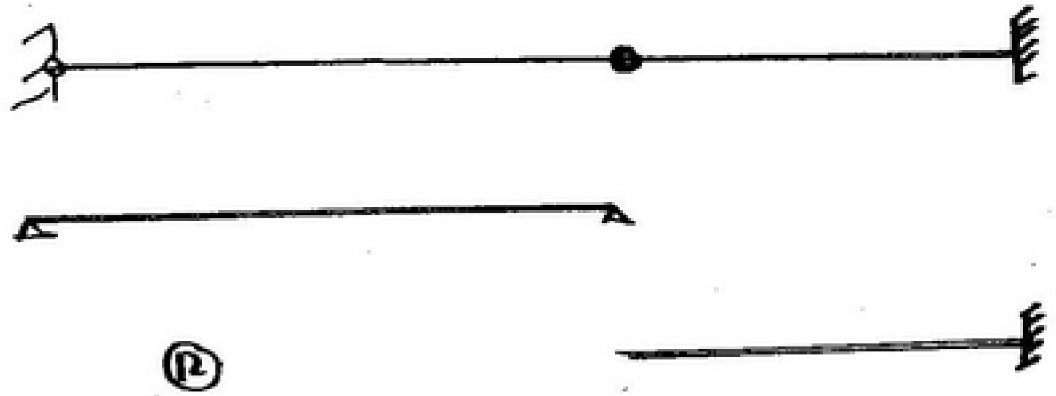
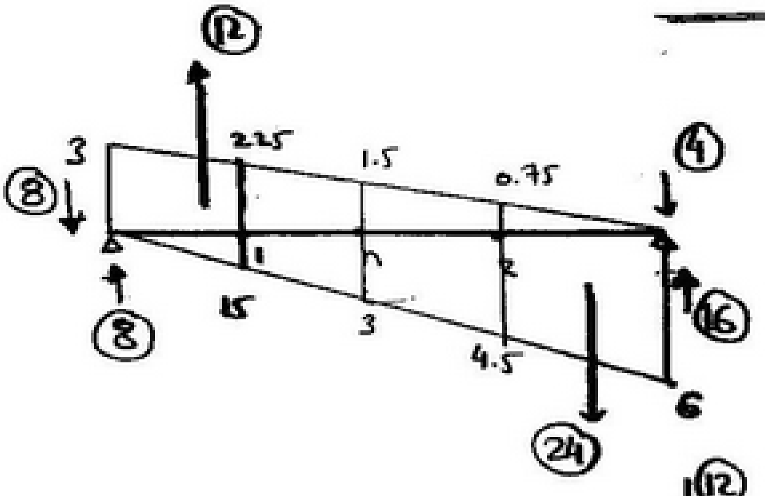
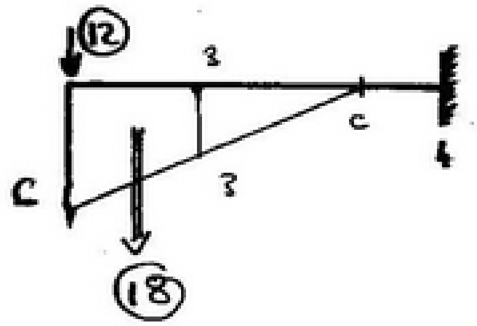
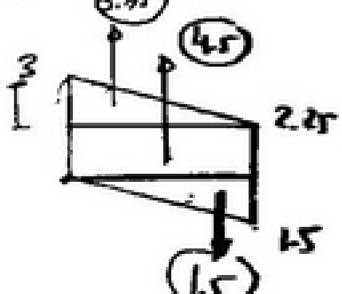
Conj







إحسب def عند ٥ نقط .



$$\delta_1 = 4.5 * 1 + 0.75 * \frac{4}{3} - 1.5 * \frac{2}{3} = \frac{1}{EI}(4.5)$$

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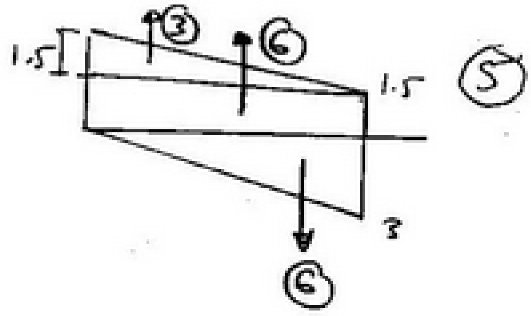
$\delta_{a} = 3 * 8/3 + 6*2 -$

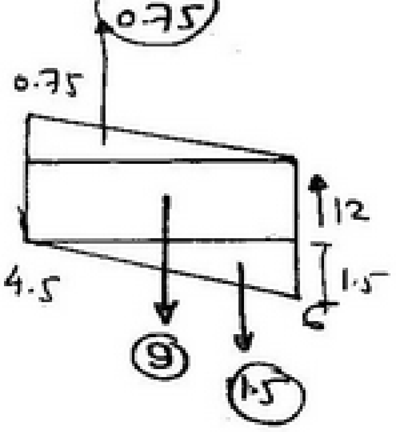
$6 * 4/3 = 12/EI$



$\delta_{2} = 12*2 + 0.75 * 2/3$

$- 9*1 - 1.5 * 4/3$

$= 13.5/EI$



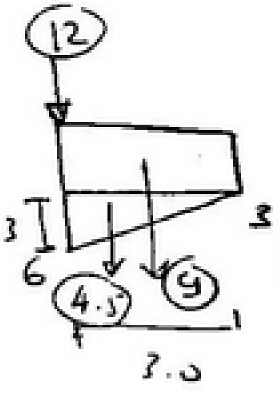
$\delta_{4} = -12*7 - 18*5 = -174/EI$

$\delta_{c} = -12*6 - 18*4 = -144/EI$

$\delta_{3} = -12*3 - 9*1.5$

$- 4.5 * 2$

$= -582$



$\underline{144} = \underline{EI} * \delta$ ثم قسمة

$(\underline{11yc})$

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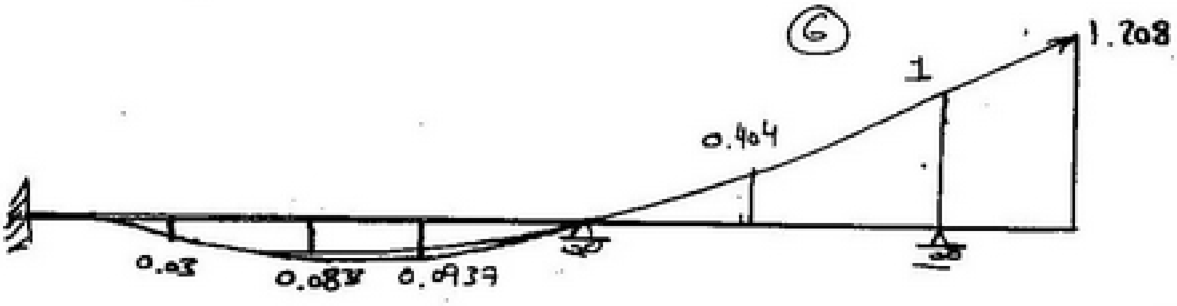

$(IL\ y_c)$

مرجعية

$$\delta_{11} x_1 + \delta_{12} x_2 = 0.0$$

$$\delta_{21} x_1 + \delta_{22} x_2 = 1.0$$

$$168 x_1 - 8 x_2 = 0.0$$

$$-8 x_1 + 2.67 x_2 = EI$$

solve

$$x_1 = 0.0208\,EI \qquad x_2 = 0.4368\,EJ$$

$$x_1 = \frac{EJ}{48} \qquad x_2 = \frac{EJ}{2.29}$$

فرض EJ بأي رقم (مثال)

$$EJ = \underline{48}$$

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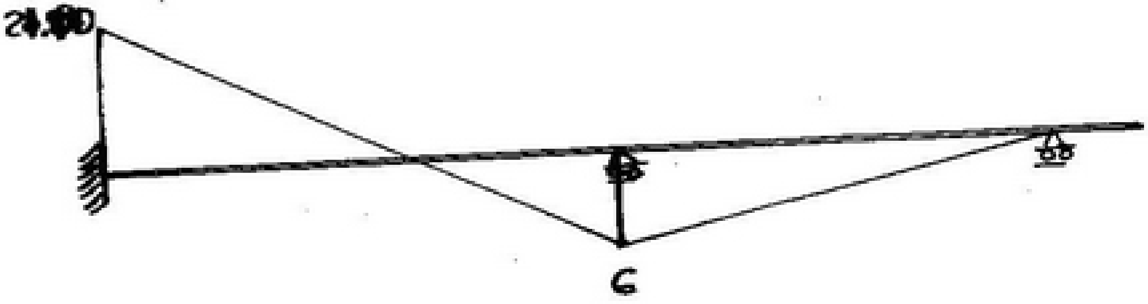
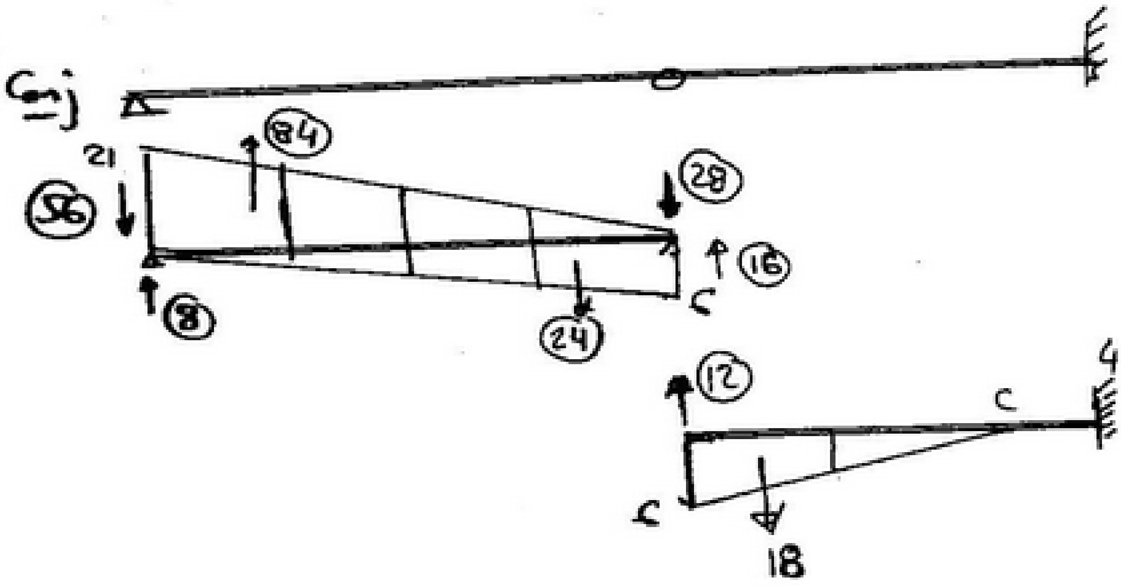
$x_1 = 1$ $\qquad\qquad X_2 = 20.966 = 21$

$$M_F = M_1 x_1 + M_2 x_2$$



(M_F)



ثم حساب الـ def عادي كما سبق مع ملاحظة

$1 \underline{rad} = \frac{48}{EI} = \theta_A$ أنه يا شغل

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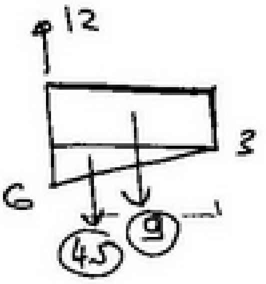
$$\delta_c = (12*6 - 18*4)\frac{1}{EJ} = \underline{\underline{zero}}$$

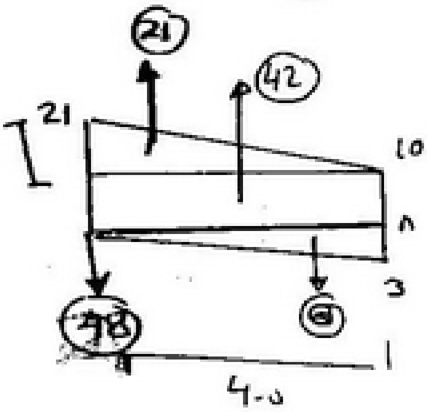
سنم ولابد

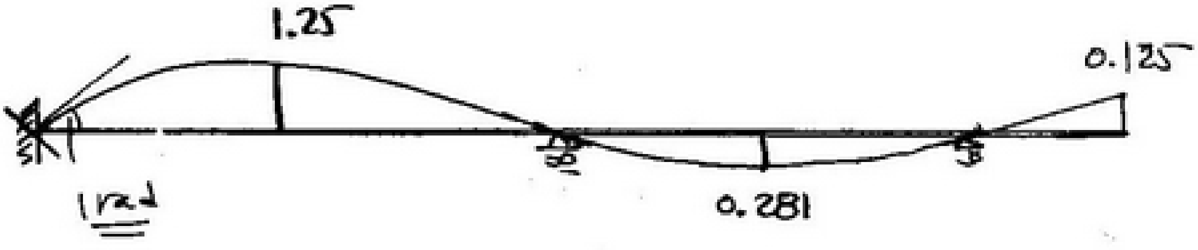
$$\delta_4 = 12*7 - 18*5 = -6/EJ$$

$$\delta_3 = 12*3 - 9*1.5 - 4.5*2 = +13.5/EJ$$



$$\delta_n = -48*4 - 6*4/3 + 42*2 + 21*8/3 = -60$$

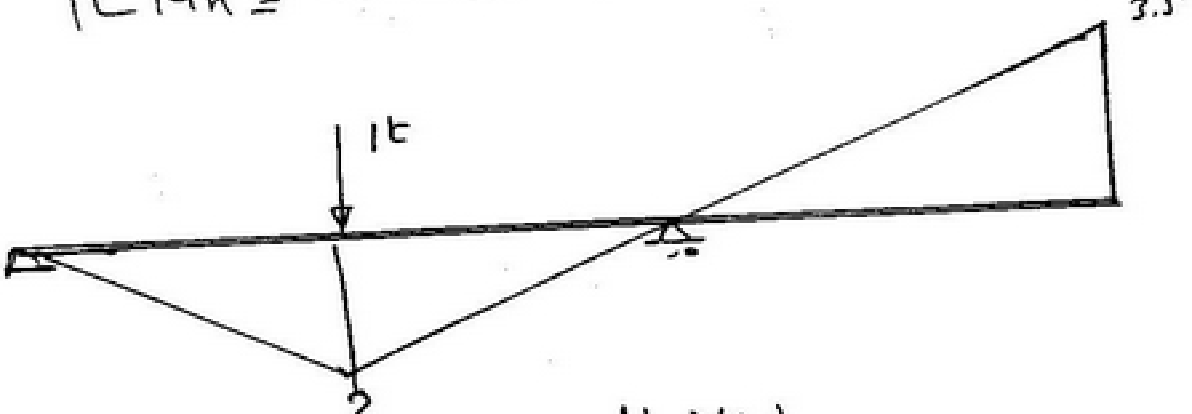




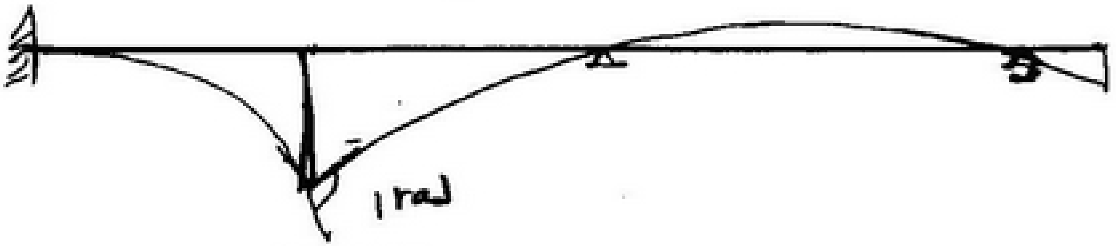
ILMA

ILMn

$ILMn = ILMno + 3\,ILYc - 0.5\,ILMA$



(IL Mno)



$ILY_A = ILY_{A0} + 0.75\,ILYc + \frac{1}{8}\,ILMA$

$ILY_B = ILY_{B0} - 1.75\,ILYc - \frac{1}{8}\,ILMA$

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19

STRUCTURE MECHANICS

2 nd Year

CIVIL

CH: INFLUENCE LINES

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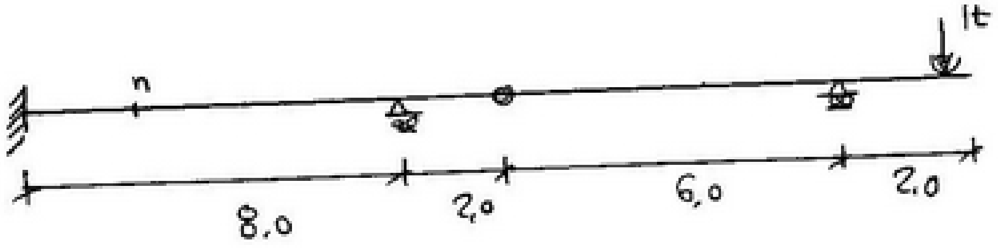
بسم الله الرحمن الرحيم

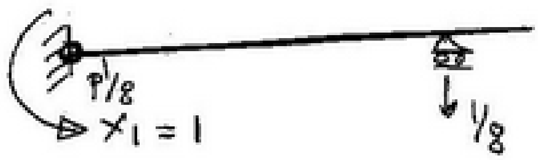
Draw the influence lines for

1. - IL M_A
   - IL Y_A, Y_B
   - IL M_n, Q_n
   - IL Q_{Ar}, IL Q_{Bl}, IL Q_{Br}
2. Calculate the max M_A due to moving line load equal to 2t/m
3. Calculate max M_A due to dead load.



Sol^n

Main System →



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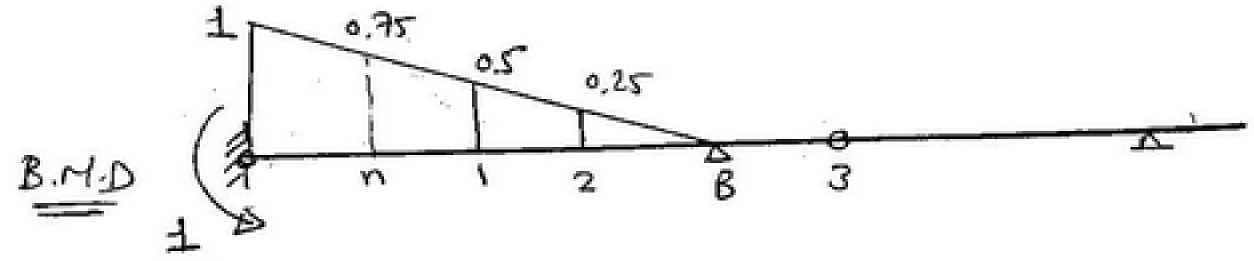
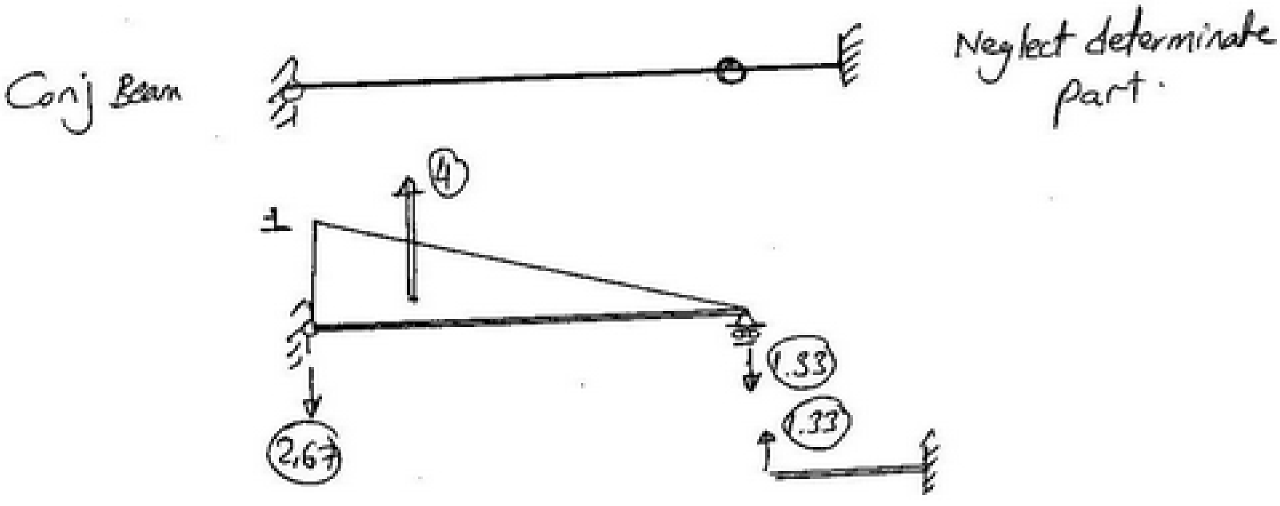




<u>def Calculations</u>

$$\delta_3 = \frac{1}{EI}(1.33 * 2) = 2.67/EI$$

$$\delta_2 = \left(-1.33 * 2 + 0.25 * 2/3\right)/EI$$

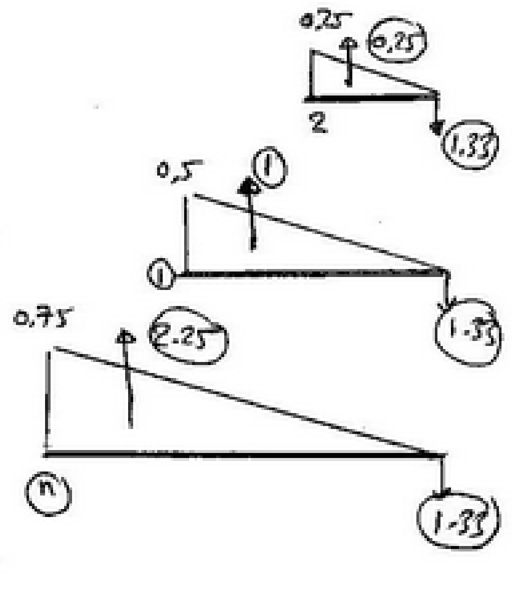
$$= -2.493/EI$$

$$\delta_1 = \left(-1.33 * 4 + 1 * 4/3\right)/EI$$

$$= -3.9867/EI$$

$$\delta_n = \left(-1.33 * 6 + 2.25 * 6/3\right)/EI$$

$$= -3.48/EI$$



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للحصول على ILMA يلزم أن تكون $\theta_A = 1 rad$

ولكن حتى الآن يلزم أن تكون الـ Elastic shear عند النقطة A = (1)

∴ يتم قسمة كل القيم المستخرجة على def 2.67

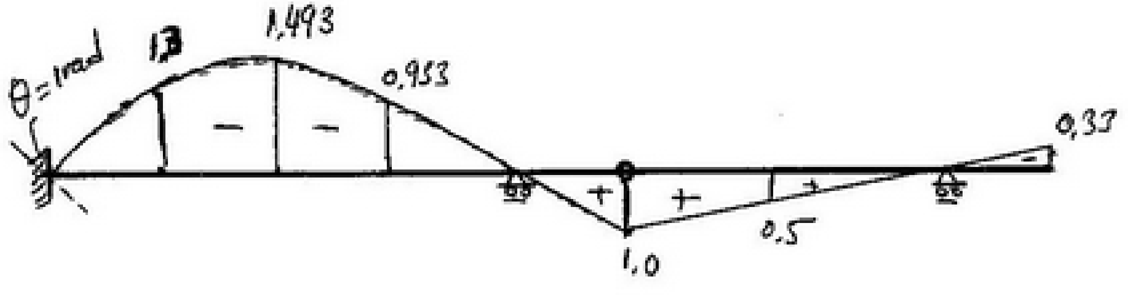
حل آخر

كما تعودنا من الـ frame نحسب δ_{11}

$$\delta_{11} = \frac{1^2 * 8}{3} = 2.67$$

∴ طبعاً من معادلة muller يجب قسمة كل القيم على δ_{11}

∴ ILMA



(ILMA)

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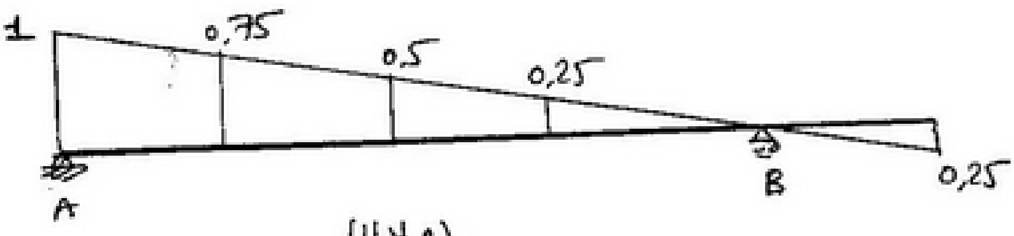
ILyA

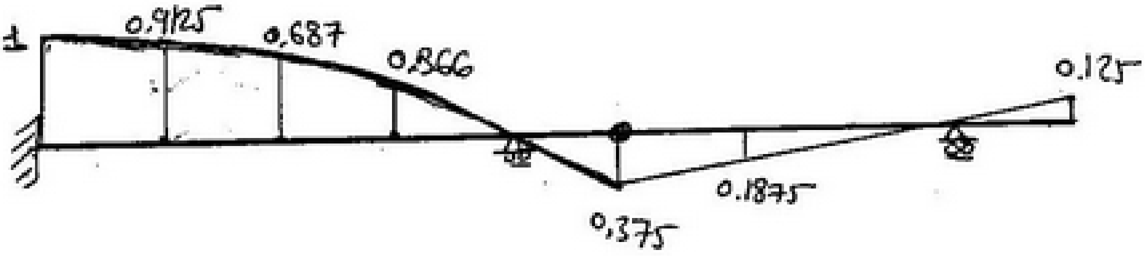
على الـ main system ارسم الـ (ILyA) وسمه (ILy_{A0})



$(ILy_A)_0$

عند وضع الـ $M_A = 1$ طن.م
فإن ردود الأفعال عند A، B
تساوي 1/8 كما هو موضح بالشكل.

$$\therefore \quad ILy_A = ILy_{A0} + \frac{1}{8}\, IL(M_A)$$



(ILy_A)

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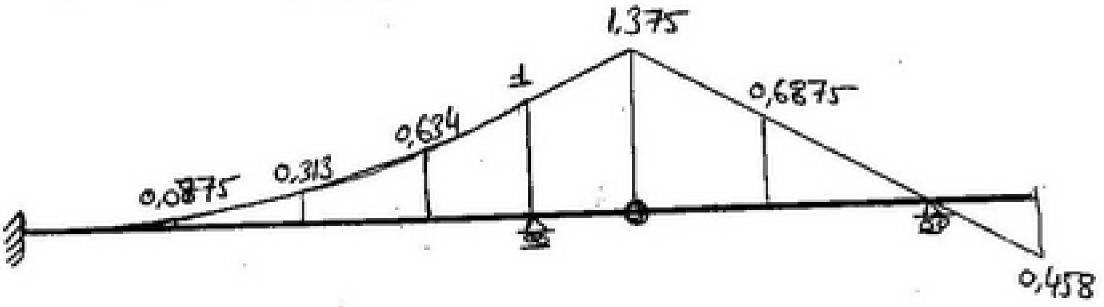
ILyB

for Part AB

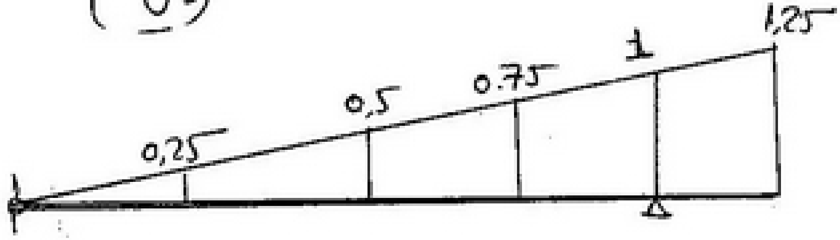
$ILy_B = 1 - ILy_A$ or

$ILy_B = (ILy_B)_o - 1/8 * ILMA$

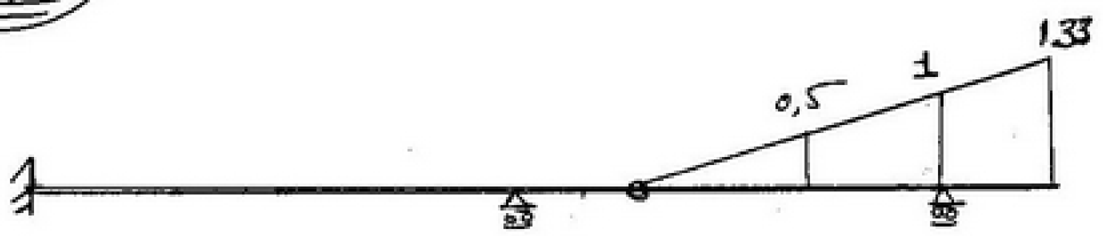


(ILy_B)

(ILy_{Bo})



ILyC



(ILy_C)

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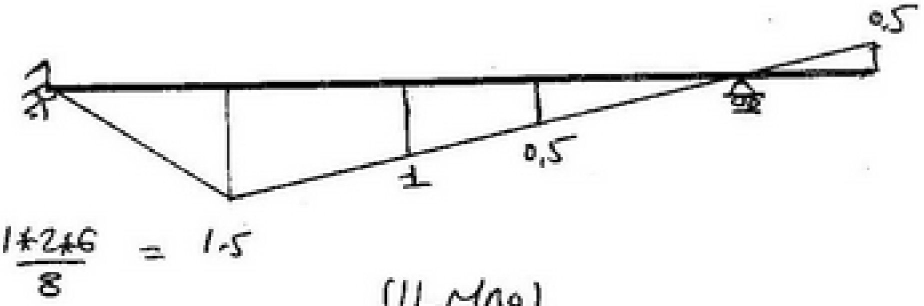
For **ILMn**

$$IL\,M_n = IL(M_n)_0 + \underline{\text{Value}} * (IL\,M_A)$$

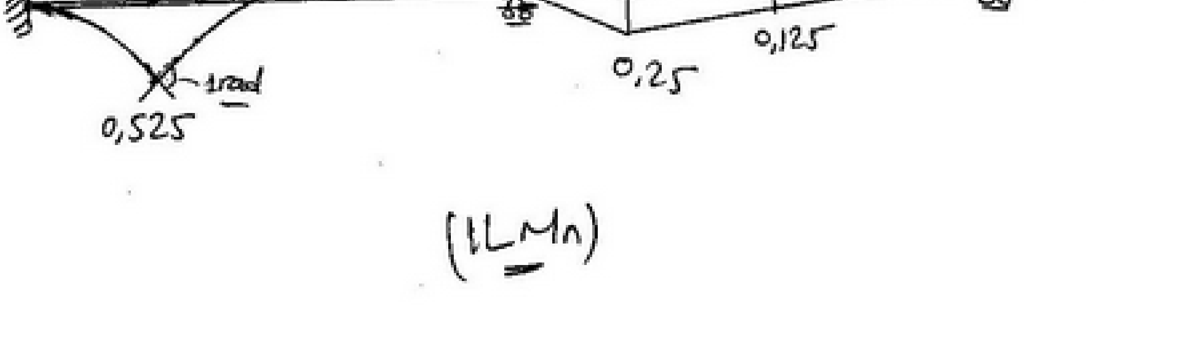
Value = مقدار العزم في الـ main system عند النقطة (n).



(ILMno)

من على الـ main system ونرسم الـ B.M.D ستبان القيمة عند النقطة (n) $= -0,75$

$$\therefore\ IL\,M_n = IL(M_n)_0 - 0.75 * IL(M_A)$$



(ILMn)

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IL Q_n

حيث انه لديك بـ $IL\,y_A, y_B$ ∴ تستطيع بسهولة
رسم بـ $IL\,Q_n$

Load A → n

$IL\,Q_n = -(IL\,y_B + IL\,y_C)$ عين مطابع

$= (IL\,y_A) - 1$

Load n → end.

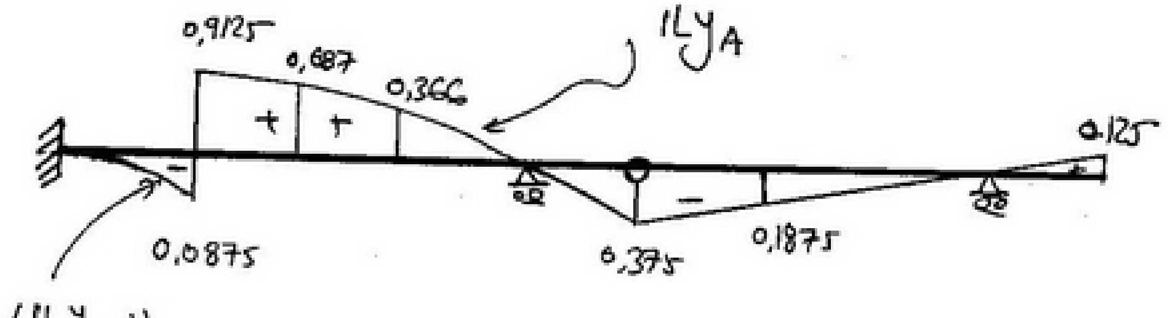
$IL\,Q_n = IL\,y_A$

OR

ارسم $(IL\,Q_n)_o$ وعوض في المعادلة المعادية

$IL\,Q_n = IL\,Q_{n_o} - \text{value} * IL\,m_A$

(1/8)



(IL Q_n)

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$\underline{\underline{ILQ_{Ar}}}$

$\underline{\underline{load}}$ $A_r \longrightarrow$ end

$$ILQ_{Ar} = ILy_A .$$

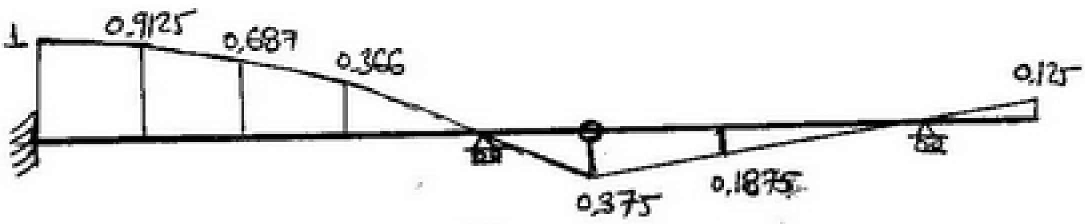
$\underline{\underline{ILQ_{BL}}}$

$\underline{\underline{load}}$ $A \longrightarrow B_L$

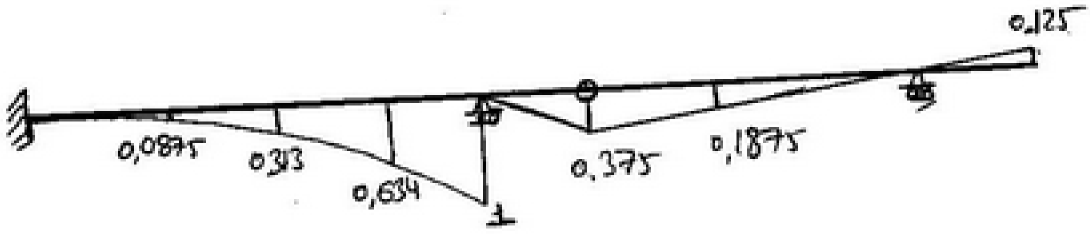
$$ILQ_{BL} = -(ILy_B + ILy_C) = (ILy_A - 1)$$

$\underline{\underline{load}}$ $B_L \longrightarrow$ end

$$ILQ_{BL} = ILy_A$$



$(IL\underline{Q}_{Ar})$



$(IL\underline{Q}_{BL})$

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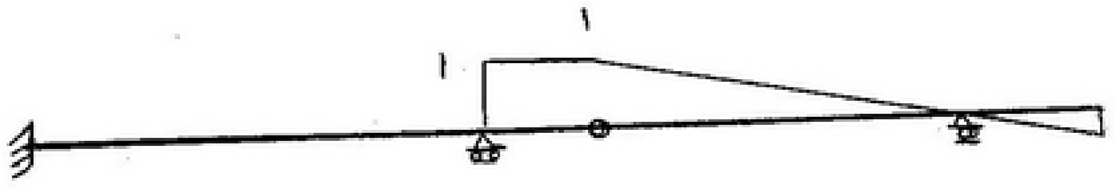
$IL Q_{Br}$

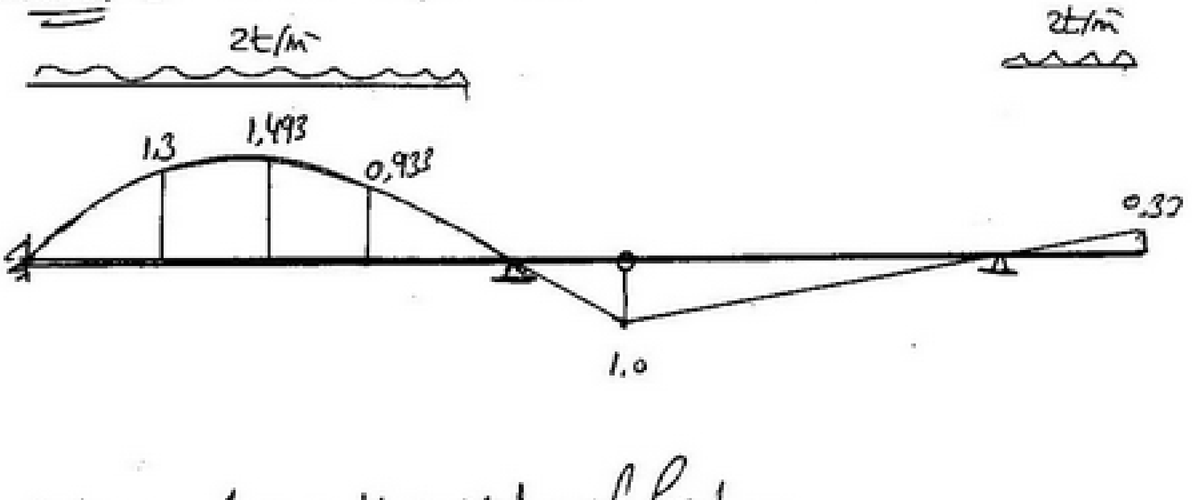
لاحظ أن هذا القطاع من الجزء المحدد استاتيكياً



بالنسبة للتحميل.

الموضح بياناته إذا كان معطى حمل موزع فيتم ضرب
قيمة هذا الحمل في مساحة (IL)

معطى moving line load مقداره 2 طن/م
لذا يتم تحميل هذا الـ I.L على الأماكن التي تعطى maxMA



$$M_A = \text{Area} * IL * \text{value of load}$$

$$= \frac{1}{2} * 0.33 * 2 * 2 + 2\left(\frac{1}{2} * 1.3 * 2 + \frac{1.3 + 1.493}{2} * 2 + \frac{1.493 + 0.933}{2} * 2 + \frac{1}{2} * 0.933 * 2\right)$$

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$M_A \simeq -\underline{\underline{12.96}} \simeq -13$

أو عكسه احنا عملنا مساحة parabolla

$M_A = 2\left(\frac{2}{3} * 1.493 * 8\right) + 2 * \frac{1}{2} * 0.33 * 2$

نتيجة الحمل

$\simeq -16.\underline{\underline{58}}$

وهذا أفضل وأقرب إلى الصحيح.

أما إذا كان نتيجة الـ D.L

$\therefore M_A =$ نتيجة السابق $+ \frac{1}{2} * 1 * 2 * 2 + \frac{1}{2} * 1 * 6 * 2$

$= -16.58 + 8 = -8.58$

يعني إننا وصلنا للقيمة الموجبة أقل من الحسابية

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"20"

STRUCTURE MECHANICS

2nd Year

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CH: INFLUENCE LINES

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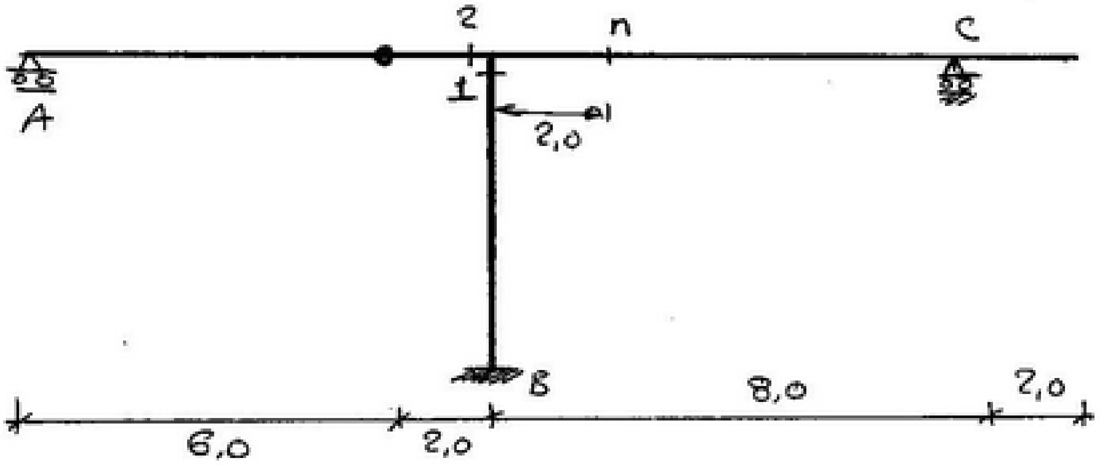
بسم الله الرحمن الرحيم

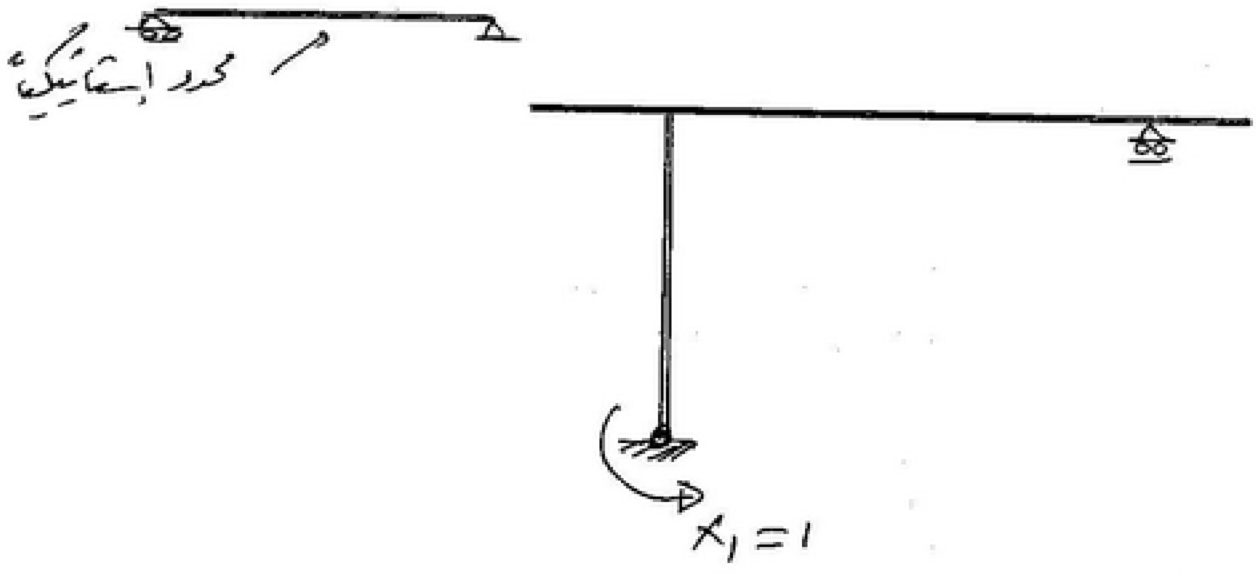


for the shown frame draw the influene lines for

M_B, M_1, X_B, Y_A, Y_B, Y_C, Q_1, N_1, Q_2, M_2,

M_n, Q_n, N_n

Sol^n



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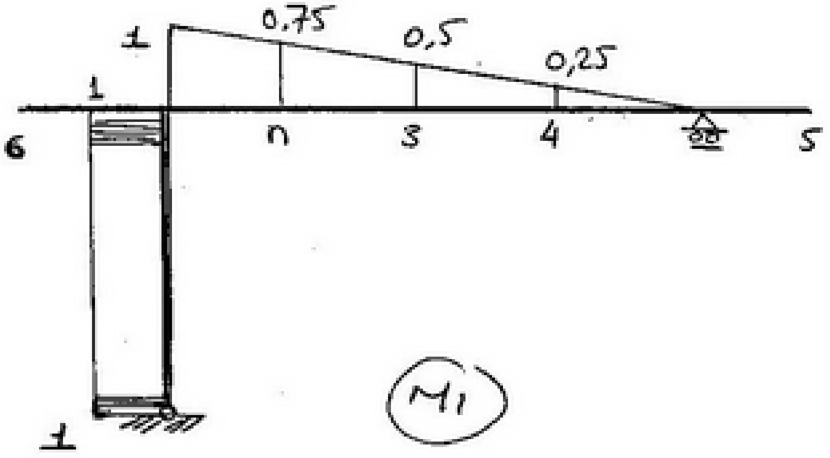
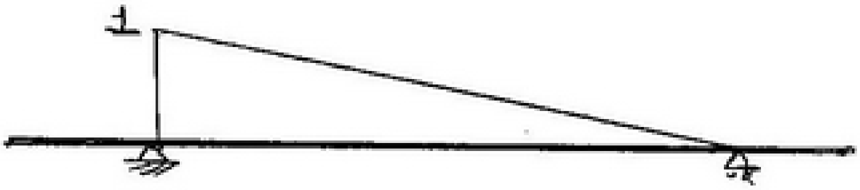


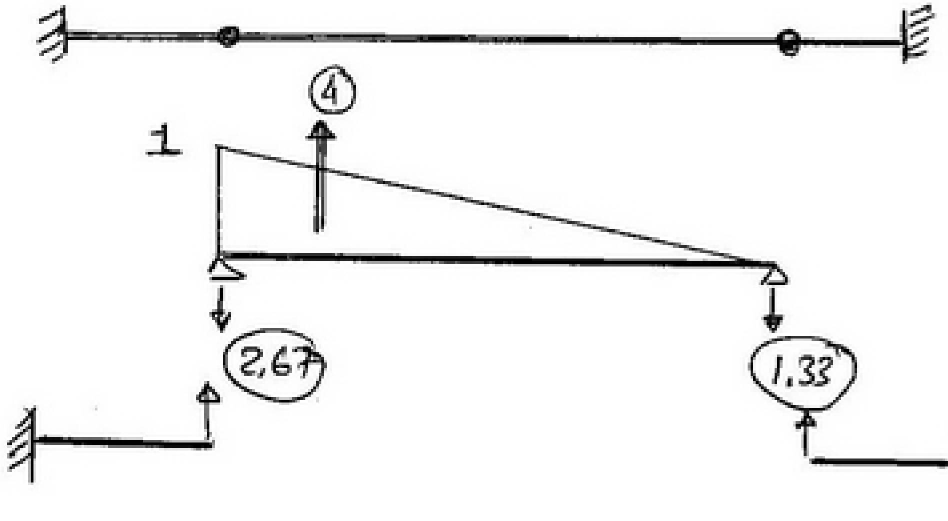
$$\delta_{11} = \int \frac{M_1^2}{EJ} dL = \frac{1}{EJ}\left(1^2 * 8/3 + 1^2 * 6\right) = \frac{8{,}67}{EJ}$$

تم اخذ Girder (الكمرة) فقط لحساب def عليها .

main Girder



Conj Beam



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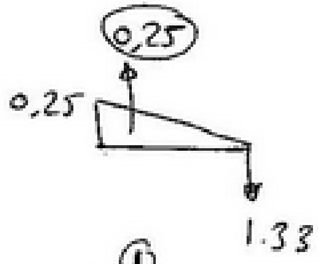
def Calculations

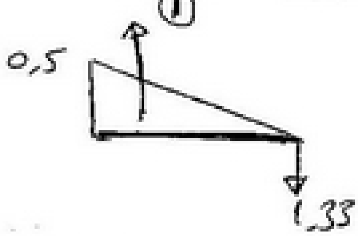
$$\delta_6 = +2.67 * 2/EJ = 5.33/EJ$$

$$\delta_5 = 1.33 * 2/EJ = 2.67/EJ$$



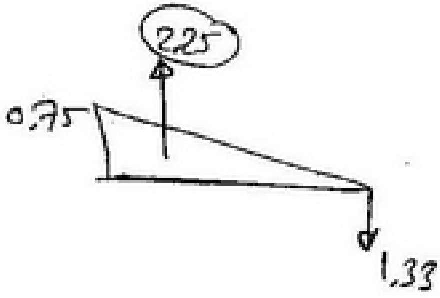
$$\delta_4 = -1.33 * 2 + 0.25 * 2/3$$

$$= -2.4933/EJ$$



$$\delta_3 = -1.33 * 4 + 1 * 4/3 = -3.987$$

$$\approx -4/EJ$$



$$\delta_n = -1.33 * 6 + 2.25 * 6/3$$

$$= -3.48/EJ$$

Applying Muller $\therefore$ $X_1 = \frac{1}{\delta_{11}}$

نعمل قسمة كل الرسم على (δ_{11}) للحصول على IL(MB)

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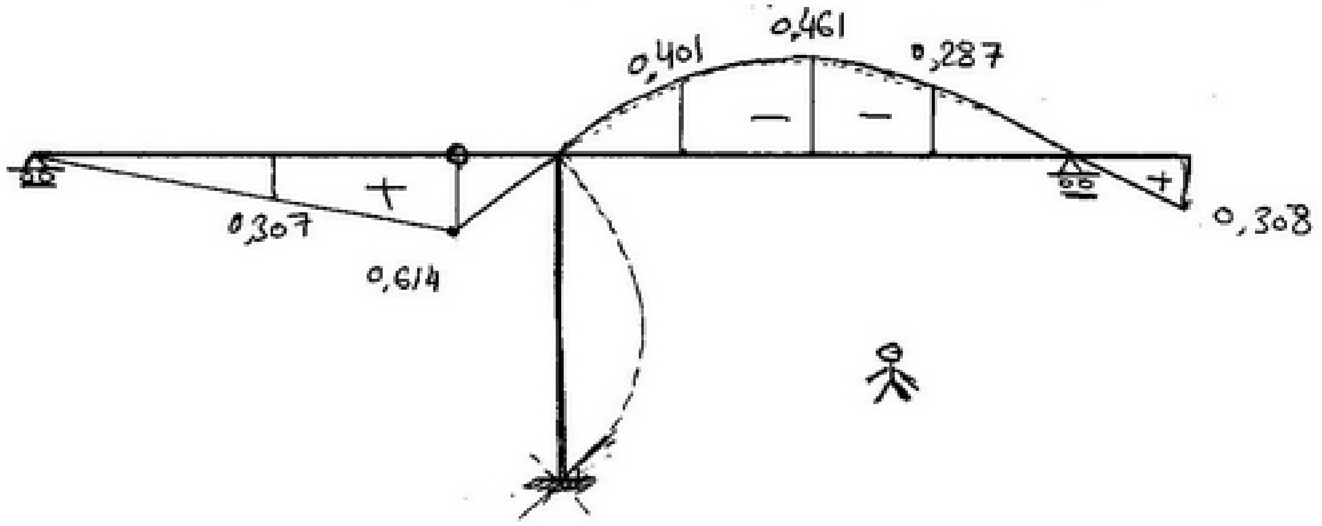

$IL(M_B) = ILM$

for sec ①

أولاً

$IL\,X_B = Zero$

نتيجة $\sum F_x = 0.0$

$\therefore \quad IL\,M_1 = IL\,M_B$

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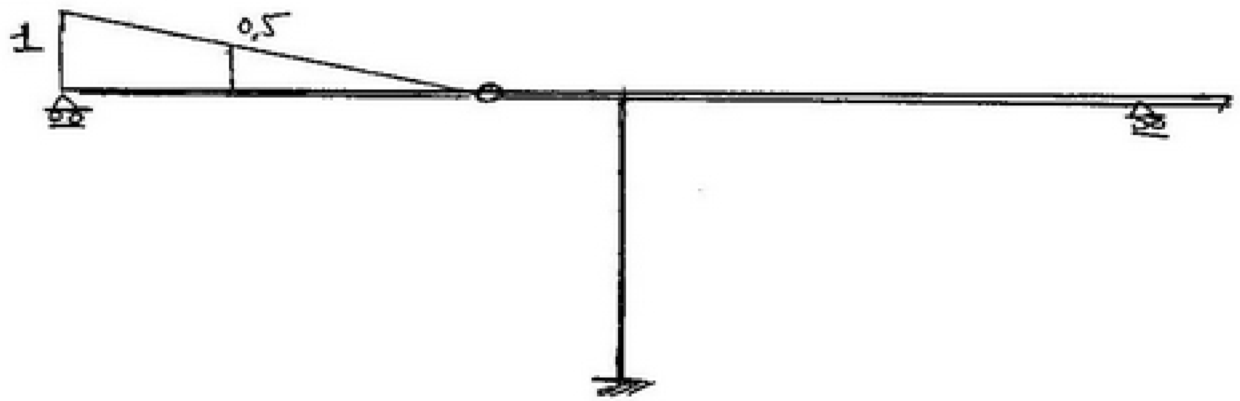
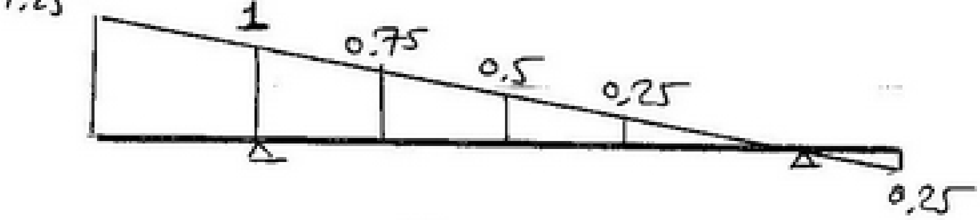
ILyA



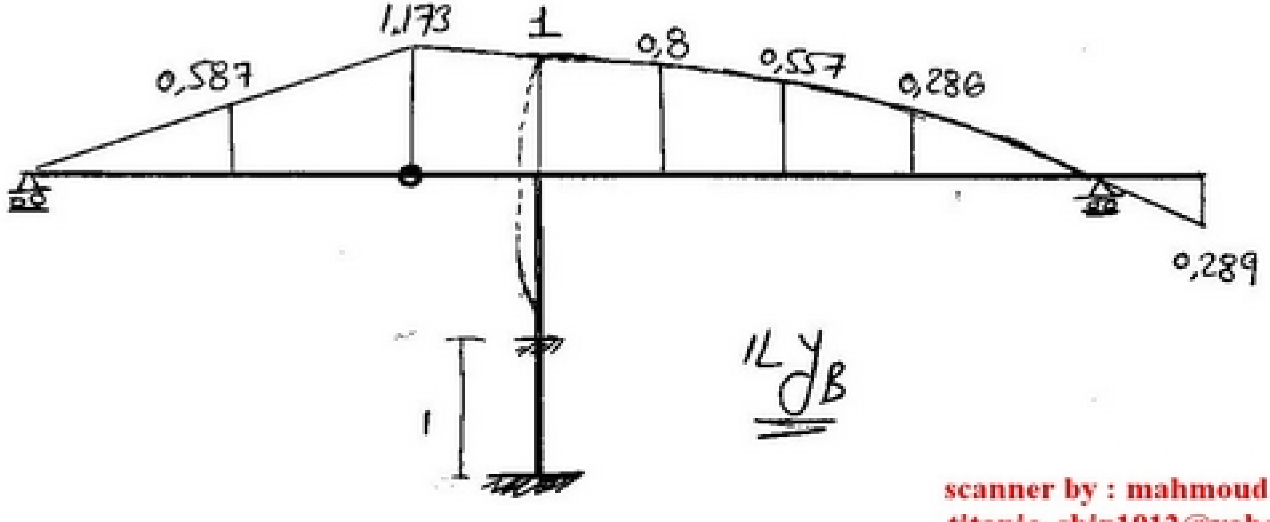
ILyA

for ILyB

$$IL\,y_B = IL(y_B)_0 + \frac{1}{8}\,ILM_A$$



$IL\,y_{B0}$



ILyB

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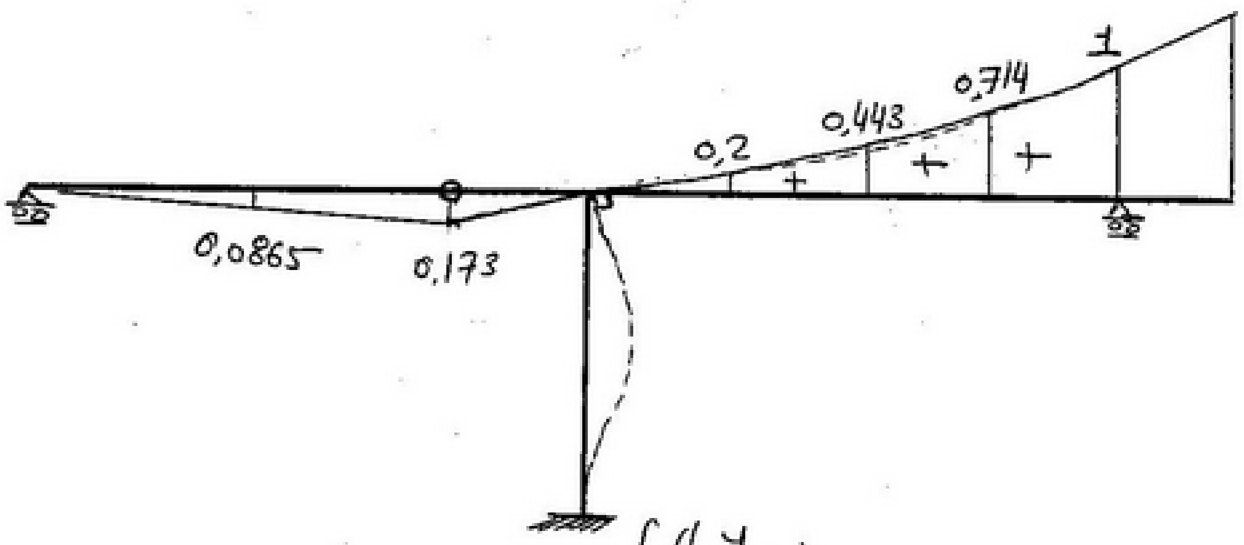
$IL y_C$

$= 1 - IL y_B$ for Part B—C

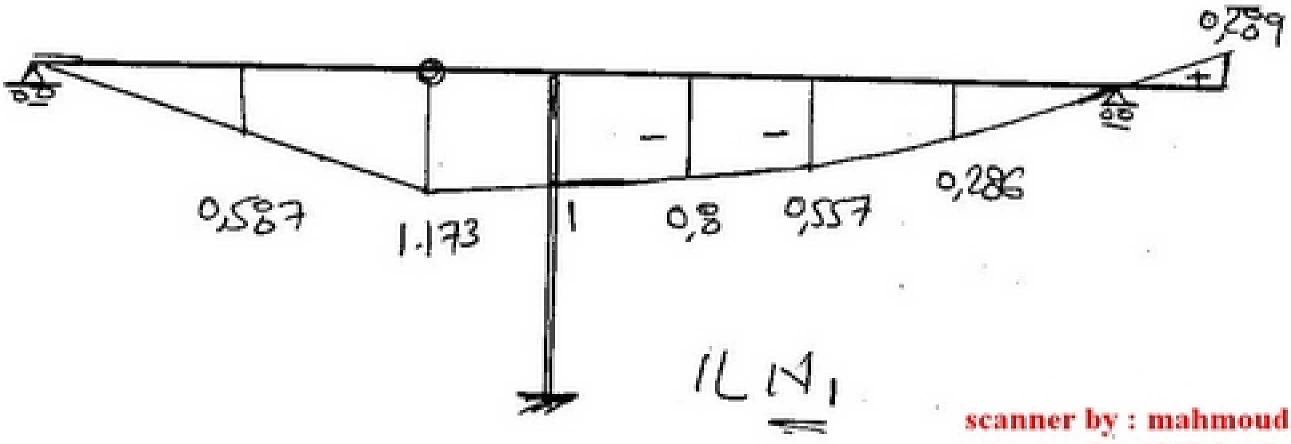


Section ①

$IL Q_1 = \text{Zero}$ Because $IL X = \text{Zero}$

$IL M_1 = IL M_B$

$IL N_1 = -IL y_B$ (Compression)



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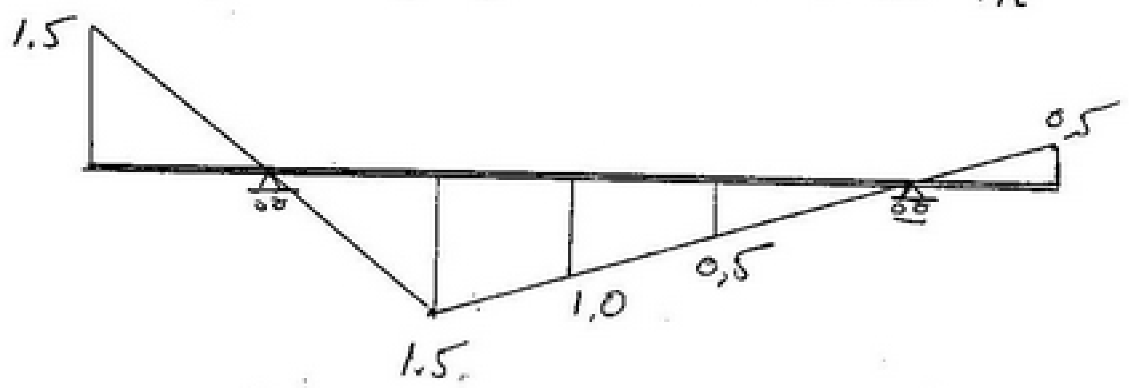
for Sec (n)

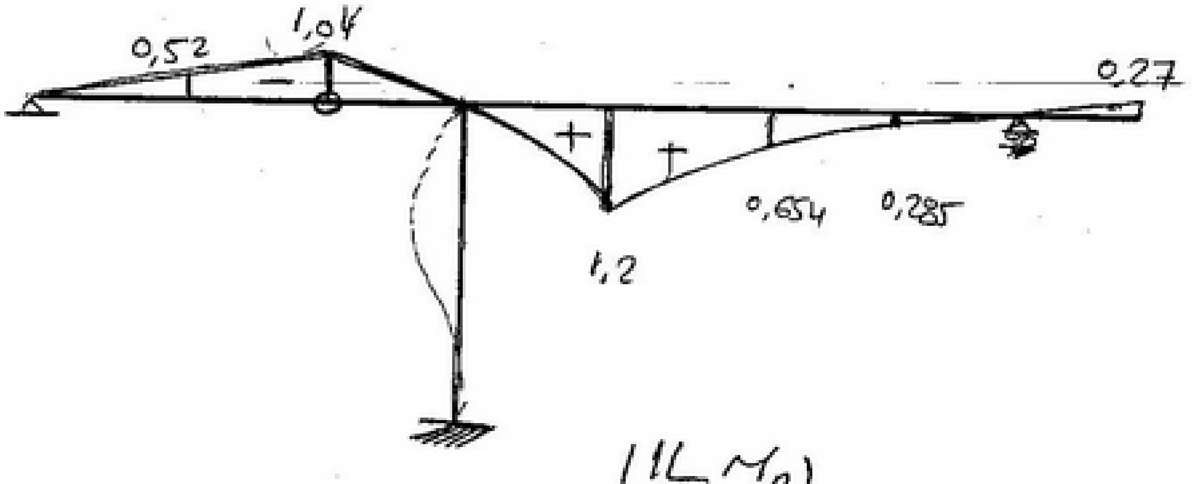
$IL\ N_n = zero$

$IL\ M_n$

$$IL\ M_n = IL(M_n)_o - 0.75 * IL\ M_A$$



$IL(M_n)_o$



$(IL\ M_n)$

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$IL\,Q_n$

load $A \rightarrow n \;\rightarrow$

$$IL\,Q_n = -IL\,y_c$$

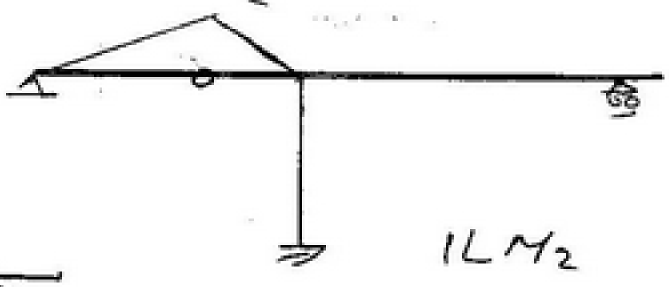
load $n \rightarrow c$

$$IL\,Q_n = IL\,y_A + IL\,y_B$$

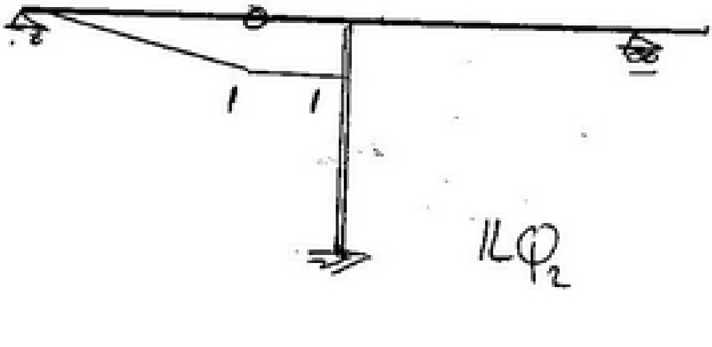
$$= 1 - IL\,y_c$$

ونرسمها بطريقة عادية جداً.

المقطع ② محدد استاتيكياً.



$IL\,M_2$



$IL\,Q_2$

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STRUCTURE MECHANICS

2 nd Year

CIVIL

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بسم الله الرحمن الرحيم

Buckling الانبعاج

Columns with initial Curvature

الأعمدة التي حدث لها انحناء قبل عملية التحميل.

① المفروض ان تكون العمود رأسي

② الوضع الناتج بالفعل حدث للعمود انحناء وبالتالي توجد مسافة (e)

③ وضع العمود بعد حدوث انبعاج.

in this Case

$$y_o = \left(\frac{P_{cr} * e}{P_{cr} - P} \right)$$

$$M_{max} = P * y_o = \left(\frac{P * P_{cr} * e}{P_{cr} - P} \right)$$

$$\sigma_{max} = \frac{P}{A} \left(1 + \frac{P_{cr} \cdot e \cdot y_c}{(P_{cr} - P)\, i^2} \right)$$

وهي نفس معادلة

$$\sigma_{max} = \frac{P}{A} + \frac{M_x * y}{I_x} + \frac{M_y * x}{I_y}$$

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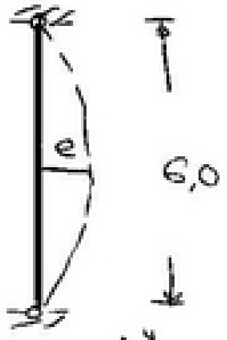
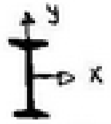
Ex for the given fixed Col^n (St 44) with initial Curvature $e = 12$ cm, and Cross section SIB No 40

$A = 118\ cm^2$, $I_x = 29210\ cm^4$, $E = 2100\ t/cm^2$

$I_y = 1160\ cm^4$

. **Req**
- Safe load
- Max stresses (fiber stresses)
- Max eccentricity
- factor of safety





SIB NO (40)

Sol^n

* Prop of section

$$i_{min} = i_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{1160}{118}} = 3.135$$

لاحظ أن L_b في الاتجاهين متساوية لذا تم الوصول إلى i_{min}

مباشرة دون الحاجة لعمل تحليل

$$\therefore P_{cr} = \frac{\pi^2 E I}{(L_b)^2} \quad , L_b = 600\ cm \text{ (Hinged-Hinged)}$$

$$= \frac{\pi^2 * 2100 * 1160}{(600)^2}$$

$$= \underline{66.78} \text{ tons}$$

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* Max eccentricity (y_o)

$$y_o = \frac{P_{cr}}{P_{cr}-P} * e = \frac{66.78 * 12}{66.78 - P}$$

$$M_{max} = P * y_o = \frac{801.36}{66.78-P}$$

∴ Max fiber stresses

$$\sigma = \frac{P}{A} + \frac{M_x}{I_x} \cdot y + \frac{M_y}{I_y} \cdot x$$

$$= \frac{P}{A}\left(1 + \frac{P_{cr} \cdot e \cdot y_c}{(P_{cr}-P) i^2}\right) \not> 1.3 \ t/cm^2 \ (st44)$$

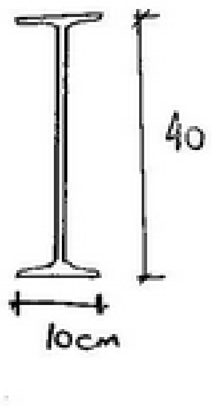
$$1.3 = \frac{P}{118}\left(1 + \frac{801.36 * 5}{(66.78-P) 3.135^2}\right)$$

مفروض حسابه لقطاع عبارة عن SIB

Trial & error بالمحاولة والخطأ

يتم استخراج (P)

$$1.3 = \frac{P}{118}\left(1 + \frac{407.68}{66.78-P}\right)$$



$$P \leq 16.77 \ ton$$

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$$\therefore\ y_o = \frac{66.78 * 12}{66.78 - 16.77} = \underline{\underline{16.024}}\ cm$$

Max eccentricity from original case.

$$= y_o - e = 16.024 - 12 \simeq 4\ cm$$

$$M_{max} = P * y_o = 16.77 * 16.024$$

$$= \underline{\underline{268.72}}\ t\text{-}cm$$

$$L_b = 6m = 600\ cm$$

$$\lambda = \frac{L_b}{i^{\circ}} = \frac{600}{3.135} = 191.39 > 96$$

$$\sigma_{pb} = \frac{6000}{\lambda^2} = \frac{6000}{191.39^2} = 0.1638\ t/cm^2$$

$$F.S = n = \frac{\sigma_{cr}}{\sigma_{pb}} \quad , \quad \sigma_{cr} = \frac{P_{cr}}{A} = \frac{66.78}{118} = 0.566\ t/cm^2$$

$$F.S = n = \frac{0.566}{0.1638} = \underline{\underline{3.46}}$$

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BFIB NO 32

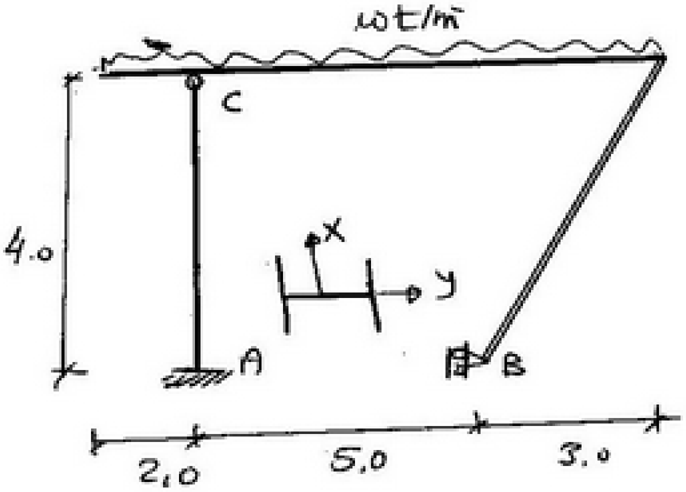
Steel 37

$I_y = 80000\ cm^4$

$I_x = 120000\ cm^4$

$A = 300\ cm^2$

$E = 2100\ t/cm^2$



req. w

Sol.

لاحظ أنه لم يذكر لنا أن العمود restricted عند

النقطة (C) من ناحية out of plane فلابد وأن نعرف أنه هكذا

العمود يعتبر من ناحية in plane ← fixed free

out of plane ← fixed-Hinged

وإن لم يذكر لنا أنه restricted تكون العمود من الناحيتين متساوي

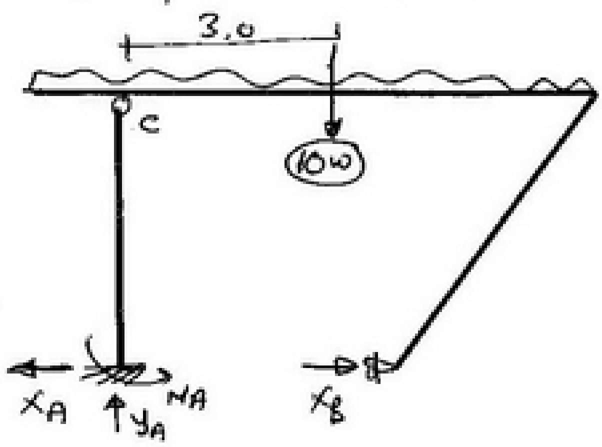
(fixed - free)

أولاً أوجد القوى والعزوم في العنصر (AC)

ΣM_c right $= 0.0$

$10w * 3 - X_B * 4 = 0.0$

$X_B = 7.5\,w$



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$\Sigma f_x = 0.0$

$x_A = 7.5w$

$\Sigma f_y = 0.0 \Rightarrow y_A = 10w$

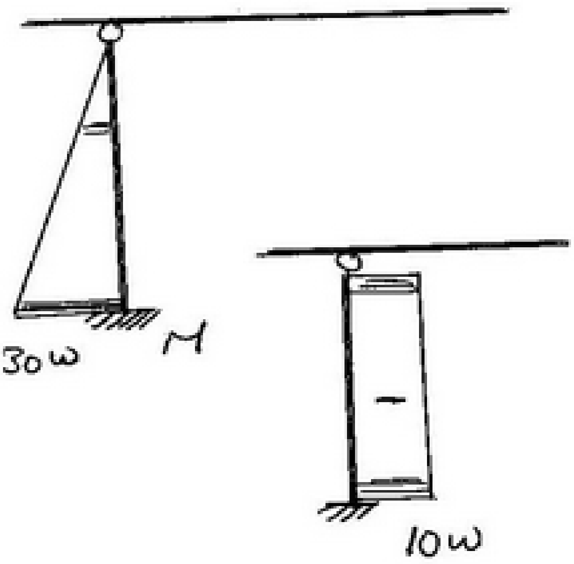
ΣM_c down $= 0.0$

$\therefore M_A = x_A * 4 = 7.5 * w * 4$

$= 30w$

$L_b = 2L$ (fixed-free)

$= 2 * 4 = 8m$



$i_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{120000}{300}}$

$= 20$

$i_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{80000}{300}}$

$= 16{,}33$

$\therefore \lambda_{max} = \frac{800}{16{,}33} \cong 49 < 104$

$\therefore \sigma_{pb} = 1{,}1 - 0{,}00005\lambda^2$

$= 1{,}1 - 0{,}00005 * 49^2 = 0{,}98 \ t/cm^2$

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$$k = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0.98} = \underline{\underline{1.122}}$$

$$M = 30\,\omega = M_x$$

$$\sigma = \frac{P}{A}\,k + \frac{M_x}{I_x}\cdot y$$

$$1.1 = \frac{10\,\omega}{300} * 1.122 + \frac{30\,\omega * 10^2}{120000} * 16$$

$$\therefore\ \omega \leq \underline{\underline{2.515}}\ t/m'$$

لا ننسى أن هذا العمود محكوم من اتجاه (x)

لذا In-plane

$$(L_{bx}) = L/2 \quad , \quad (L_{by}) = L$$

$$P_{cr_1} = \frac{\pi^2 * EI_x}{(L_{bx})^2}$$

$$P_{cr_2} = \frac{\pi^2 * EI_y}{(L_{by})^2}$$

ثم أختار P_{cr} الأقل من (P_{cr_1}, P_{cr_2})

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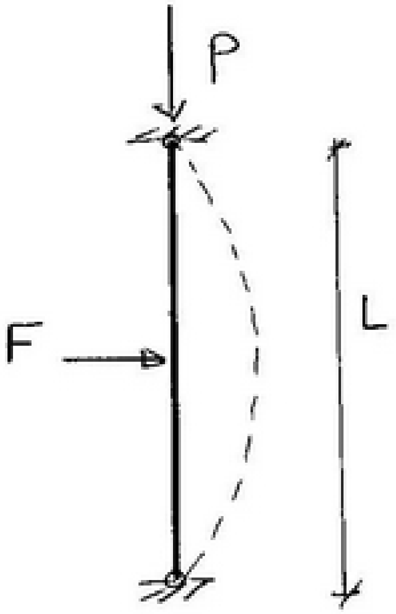
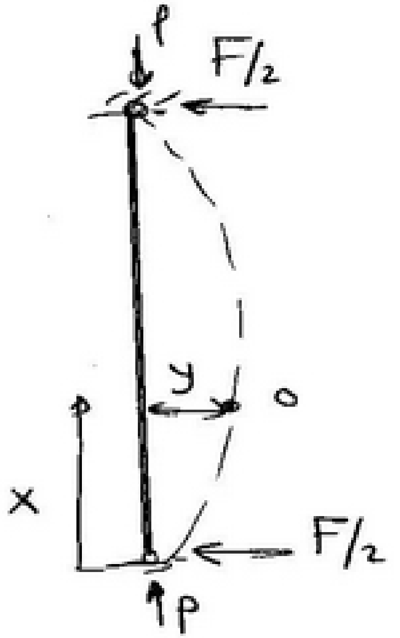
أى إثبات من ب buckling

يحمل من الوسط على حساب العمود





at (o)

$$M = \frac{F}{2}(x) + P * y$$

$$EJy'' = -M = -P * y - F/_2 (x)$$

$$\therefore \; y'' + \frac{P}{EJ} y = -\frac{F}{2EJ}(x)$$

But $c^2 = P/_{EJ}$

$$\therefore \; y'' + c^2 y = \frac{-F}{2EJ}(x)$$

$$\therefore \; y = A\cos cx + B \sin cx + P.I$$

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$$P.I = \frac{1}{D^2 + C^2}\left(\frac{-F}{2EI}(x)\right)$$

$\underline{D^2} = 0.0$

$$\therefore P.I = \frac{1}{C^2}\left(\frac{-F}{2EI}(x)\right) \quad , \quad C^2 = P/_{EI} \Rightarrow EI = P/_{C^2}$$

$$= \frac{1}{C^2}\left(\frac{-F}{2P/C^2}(x)\right. \quad = \frac{-1}{\cancel{C^2}}\left(\frac{\cancel{C^2} * f}{2P}(x)\right.$$

$$= \frac{-F}{2P}(x)$$

$$\therefore y = A\cos Cx + B\sin Cx - \frac{F}{2P}(x)$$

$\underline{\underline{B.Cs}}$ at $x = 0.0 \Rightarrow y = 0.0$

$$\therefore A = 0.0$$

$$\therefore y = B\sin Cx - \frac{F}{2P}(x)$$

at $x = \frac{L}{2} \Rightarrow y = y_{max}, \ \frac{dy}{dx} = 0.0$

$$\therefore \frac{dy}{dx} = 0.0 = CB\cos Cx - F/_{2P} \quad \text{at } x = L/_2$$

$$0.0 = C * B * \cos\frac{CL}{2} - F/_{2P}$$

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$$\therefore B = \frac{F/2P}{C \cos CL/2}$$

$$\therefore y = \frac{(F/2P)}{C \cos \frac{CL}{2}} * \sin Cx - \frac{F}{2P}(x)$$

$y = y_{max}$ at $x = L/2$

$$\therefore y_{max} = \frac{(F/2P)}{C \cos CL/2} * \sin \frac{CL}{2} - \frac{F}{2P} * L/2$$

$$y_o = y_{max} = \frac{F}{2P * C} \tan \frac{CL}{2} - \frac{FL}{4P}$$

$$\underline{\underline{Max\ B.M}} = \frac{FL}{4} + P * y_o$$

$$= \frac{\cancel{P} * F}{2C * \cancel{P}} \tan \frac{CL}{2} - \frac{FL}{4\cancel{P}} * \cancel{P} + \frac{FL}{4}$$

$$M_{max} = \frac{F}{2C} \tan \frac{CL}{2}$$

$$\sigma = \frac{P}{A} + \frac{M}{I} \cdot y \ngtr \sigma_{P.C}$$

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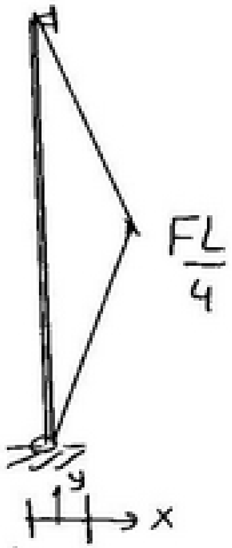
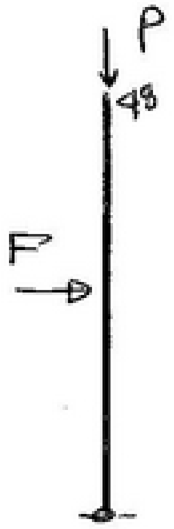
المسأله لو كانت عاديه . تم حساب العزوم = $\frac{FL}{4}$

$M_y = \frac{FL}{4}$

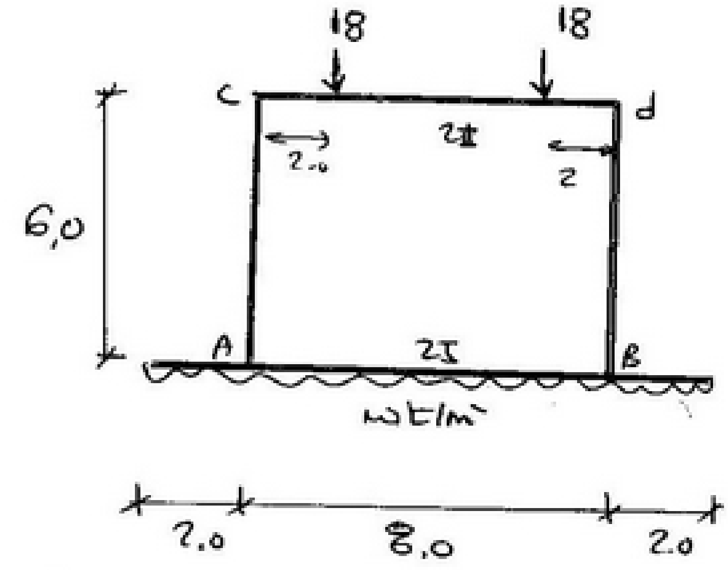
$P = P$





$$\sigma = \frac{P}{A}k + \frac{M_y}{I_y} \cdot x \ngtr \sigma_{p.c}$$

draw B.M.D, S.F.D, N.F.D



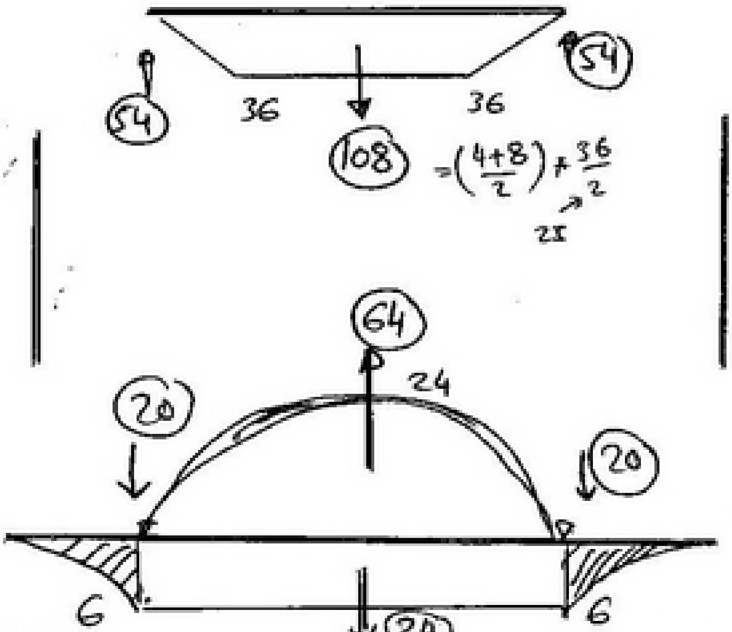
from Symmetry $M_A = M_B$

$M_C = M_d$

$\Sigma F_y = 0.0 \Rightarrow 18 + 18 = w * 12$

$\therefore w = 3 \, t/m'$

ضع نفسك داخل
loop



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at (A)

$$M_B\left(\frac{8}{2}\right) + 2M_A\left(\frac{8}{2}+6\right) + M_C(6) = -6\,r_A$$

(M_B → M_A)

$$24M_A + 6M_C = -6 * 20 = -120 \quad \rightarrow (1)$$

at (C)

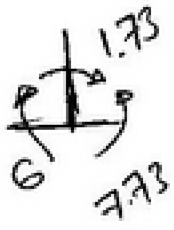
$$M_A(6) + 2M_C\left(6+\frac{8}{2}\right) + M_d\left(8/2\right) = -6\,r_C$$

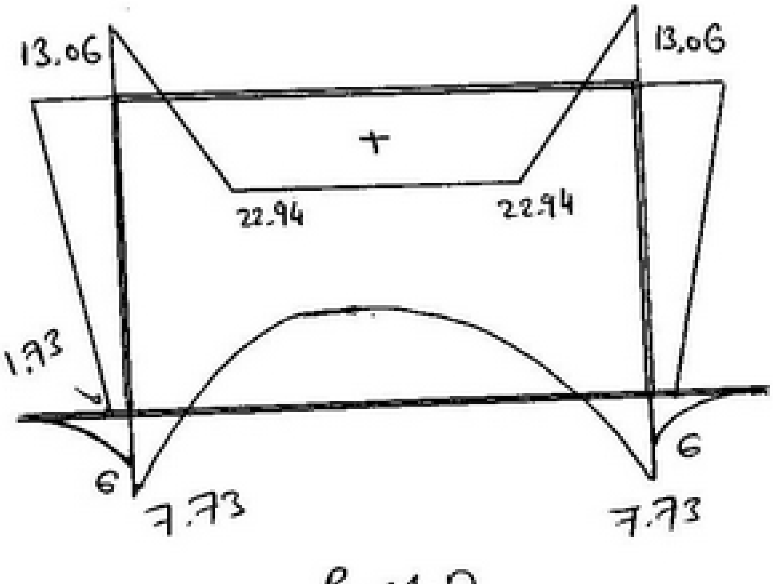
(M_d → M_C)

$$6M_A + 24M_C = -6 * 54 = -324 \quad \rightarrow (2)$$

$$M_A = -1.73$$

$$M_C = -13.06$$





B.M.D

S.F
N.F زي الـ free body

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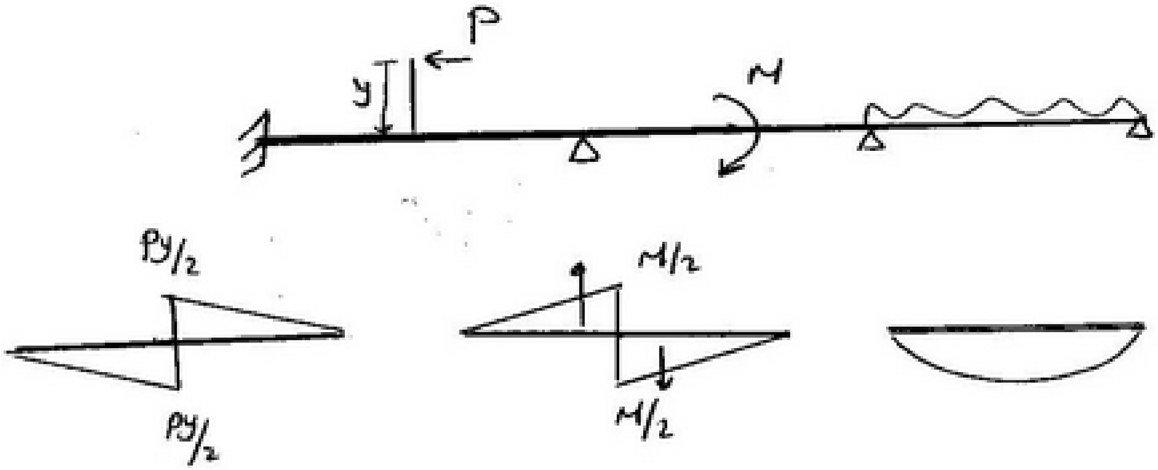
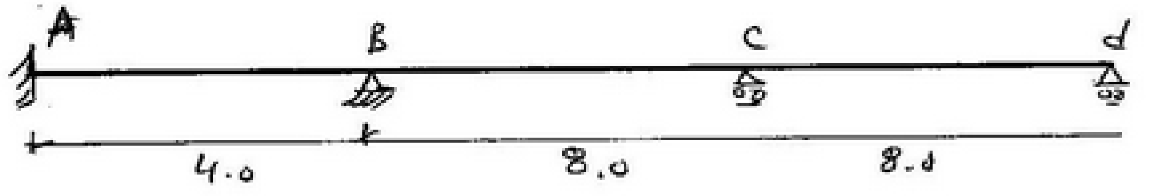
ملاحظات



تختلف تماماً عن

مثال buckling تثبيت بجزء شاذ



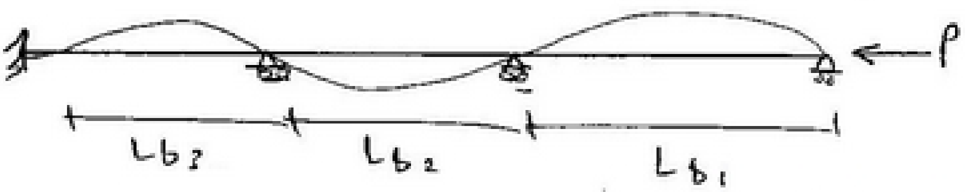
فإن الكمرة ستتمدد من الجزء BCd ثم تحدث أي التواء

لذا $L_b = (0.7 \times 4)$

نتيجة لأحمال (P)

ناخذ الأكبر من

$L_{b3} < L_{b2} < L_{b1}$



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Co... ...me	:	Structural Mechanics (2)	Final Exam	
Cou... Code	:		Date	: ...5.20...
Level	:	Second Year Civil	Time	: ... H...
Department	:	Structural Engineering	No. of pages	:
Term No.	:	2	No. of Questions	:

2008

Zagazig University
Faculty of Engineering

SOLVE AS YOU CAN

Problem No. (1) *(10 marks)*

Figure (1) shows a statically indeterminate continuous beam, using the three moment equation method, draw the **B.M.D. and S.F.D.** . Also, compute the rotation at point **B** due to ;

a) Given loads

b) Vertical settlement at **B = 2cm** **(EI = 12000 t.m^2)**

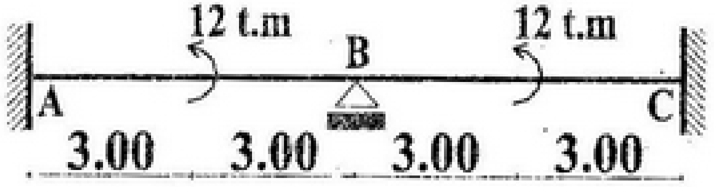

Fig. (1)

Problem No. (2) *(10 marks)*

Figure (2) shows a statically indeterminate structure, using the three moment equation method, draw the **B.M.D., S.F.D. and N.F.D.** .Also, compute the vertical deflection at point A due to the given loads.

(EI = 10000 t.m^2)

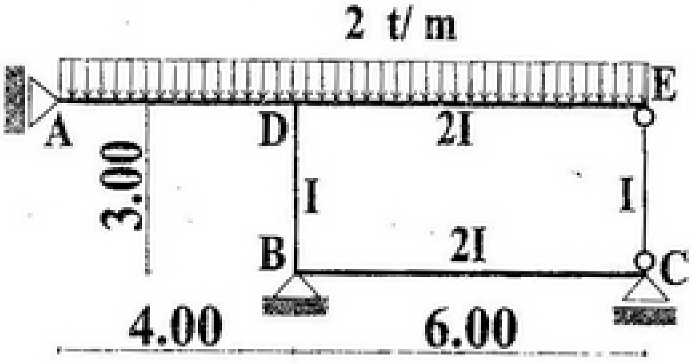

Fig. (2)

Problem No. (3) *(11 marks)*

For the circular cross-section column **BD** (Steel 37) shown in Fig. (3) , determine the maximum permissible load **P** and the factor of safety against buckling.

E= 2000 t/ cm^2 , A=125 cm^2,

$I_x = I_y = 9000$ cm^4

$\sigma_{pt} = 1.2 \;\; t/cm^2 \qquad \sigma_{pc} = 1.1 \;\; t/cm^2$

$$\sigma_{pb} = \frac{6000}{(\lambda)^2} \quad \text{for} \quad \lambda = \frac{l_b}{i} \geq 104$$

$$\sigma_{pb} = 1.1 - 0.00005(\lambda)^2 \quad \text{for} \quad \lambda < 104$$

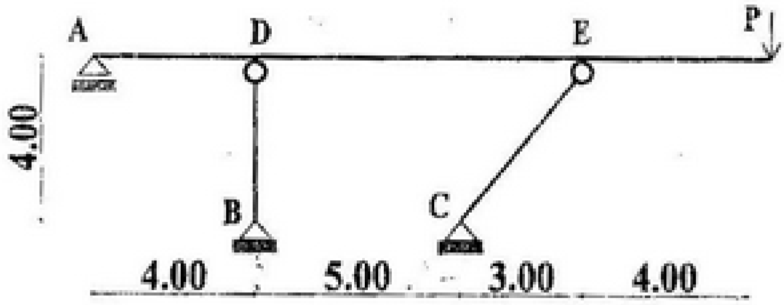

Fig. (3)

اقلب الصفحة من فضلك

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Problem No. (4) *(11 marks)*

For the beam shown in Fig. (4), calculate and draw the influence lines for Y_C ,M_A, Q_E , Q_F and M_F. Also, find the maximum values for Y_C and M_F due to 2t/m dead load and 3 t/m live load

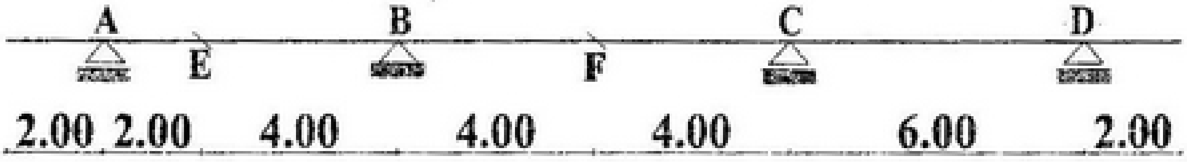

Fig. (4)

Problem No. (5) *(12 marks)*

For the shown statically indeterminate trussed beam (Fig. 5), introduce the influence lines for Y_A , M_B , Q_m and M_m .

EI_b = 20000 t.m^2 **EA_b = 80000 t** **EA_{links} = 40000 t**

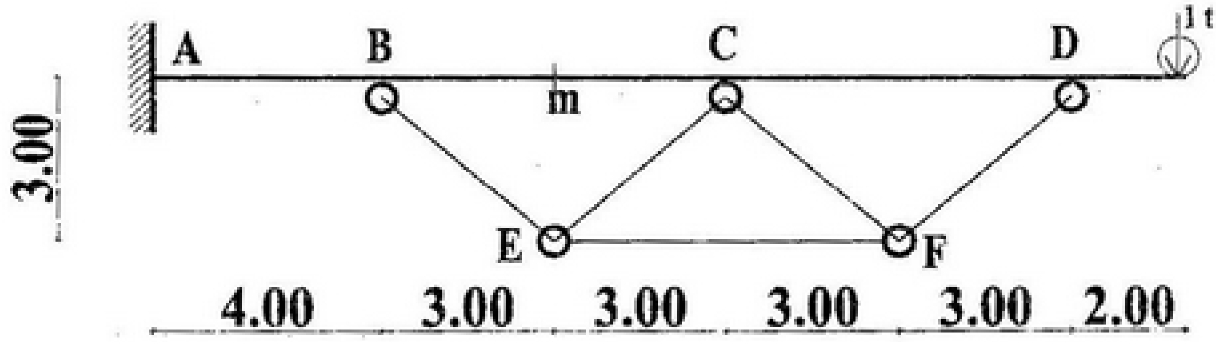

Fig. (5)

Problem No. (6) *(12 marks)*

a) For the structure shown in figure (6-a), without calculations, sketch S.F.D, N.F.D., B.M.D. , the elastic curve, and the main steel reinforcement.

b) For the structure shown in figure (6-b), without calculations, sketch the influence lines for Y_C , N_K , N_P , N_n , M_M and Q_L .

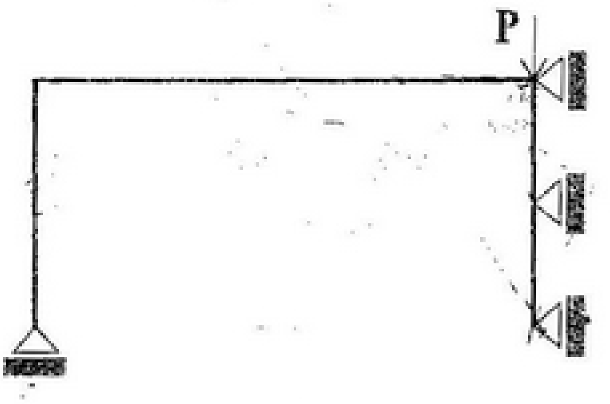

Fig. (6-a)

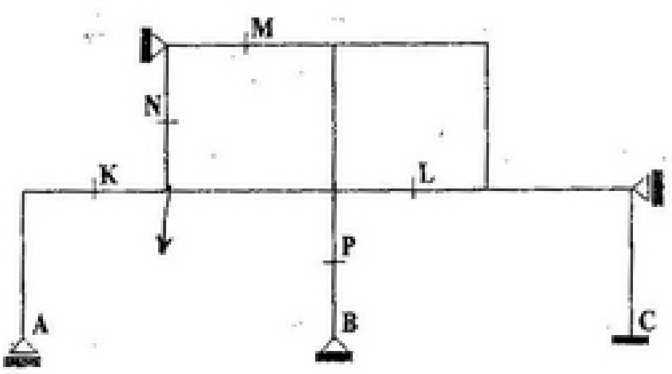

Fig. (6-b)

Prof. Dr. Sayed Abd-El Salam
Dr. Hosain Bondok

Prof.Dr. Osman Shallan
Dr. Hanaa Elsayed

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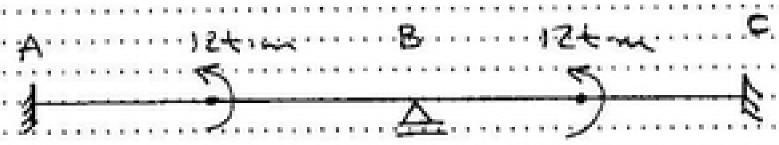
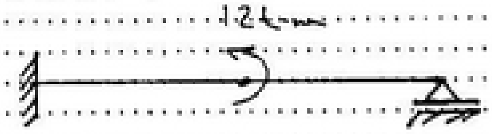
titanic_ship1912@yahoo.com

problem ①

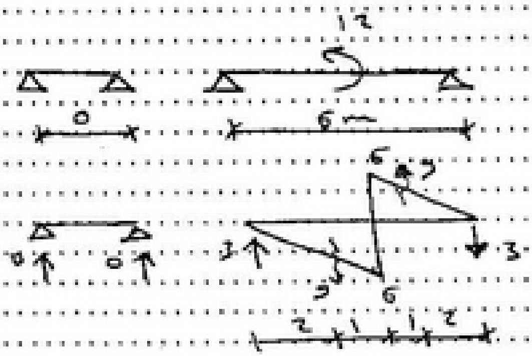
given loads



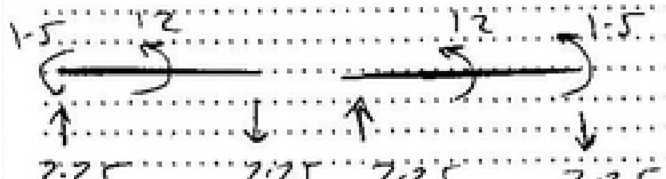
بما ان الوضع عامل تماثل (حول Support)
ناخد نصف المسألة ونضع Roller عند خط التماثل



elastic Reaction



$R_a = 3$ ton

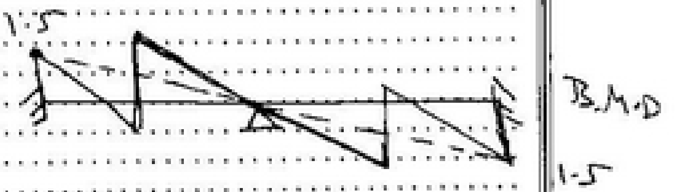


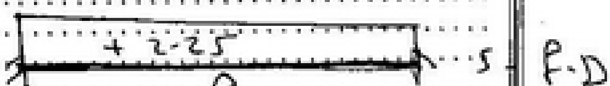
eqn at ⓐ

$$M_a(0) + 2M_a(0+6) + M_b(6) = -6R_a$$

$$12 M_a = -6 \times 3$$

$$M_a = -1.5 \text{ t.m}$$





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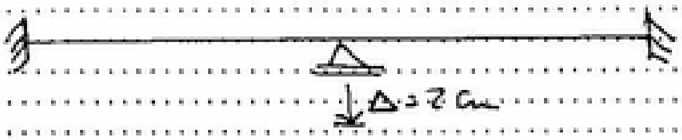
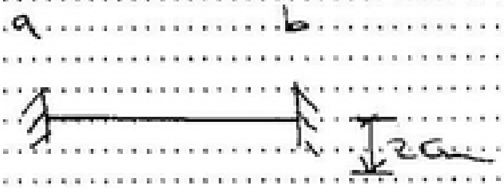
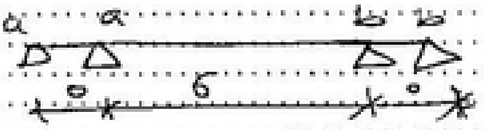
b_ settelment at b = 2 Cm



وضع كأنه لل Support
نأخذ نصفها له
(وضع Fixed) كأنه





apply at (a)

$$M_a(0) + 2M_a(0+6) + M_b(6) = +6 \times 12000 \times \left[\frac{0-0}{0} + \frac{0-2}{600}\right]$$

$$12M_a + 6M_b = -240 \longrightarrow (1)$$

apply at b

$$M_a(6) + 2M_b(6+0) + M_b(0) = 6 \times 12000 \times \left[\frac{2-0}{600} + \frac{2-2}{0}\right]$$

$$6M_a + 12M_b = +240 \longrightarrow (2)$$

$$\therefore \; M_a = -40 \qquad M_b = +40$$

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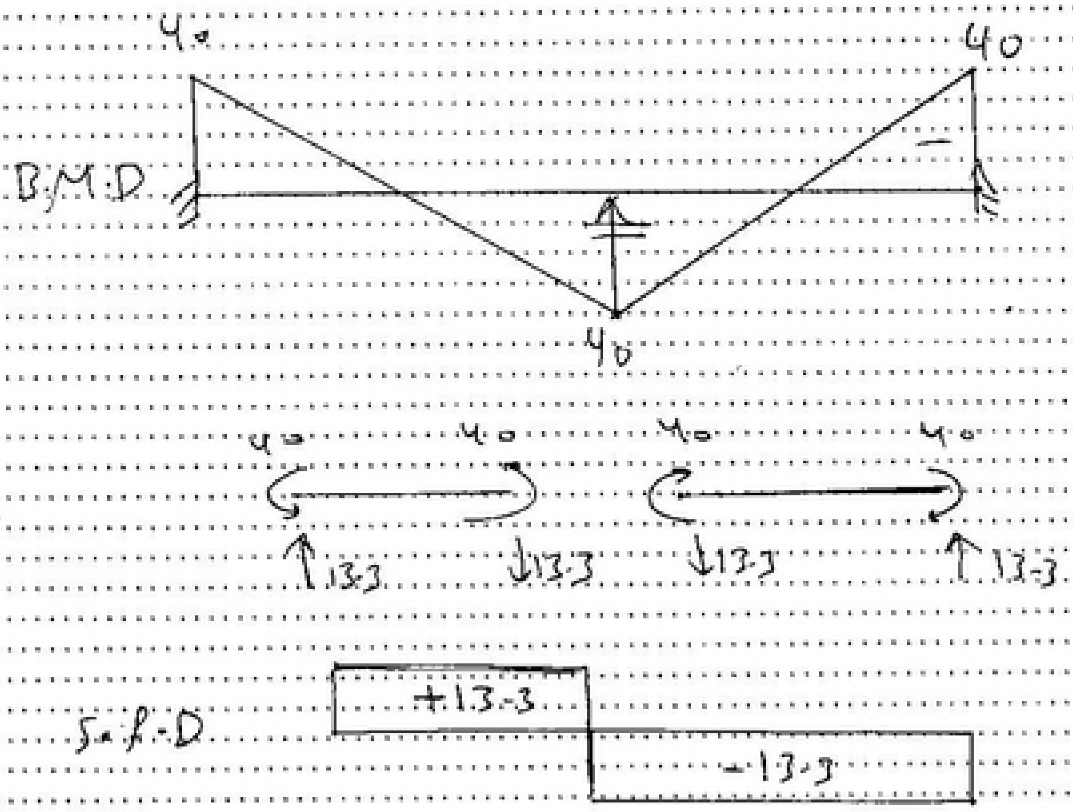

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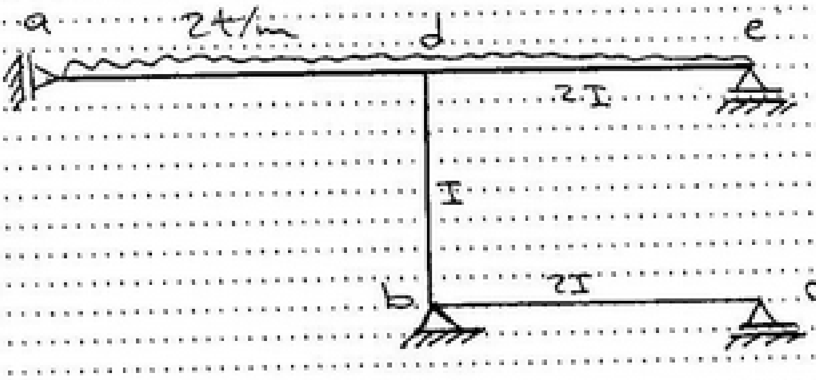
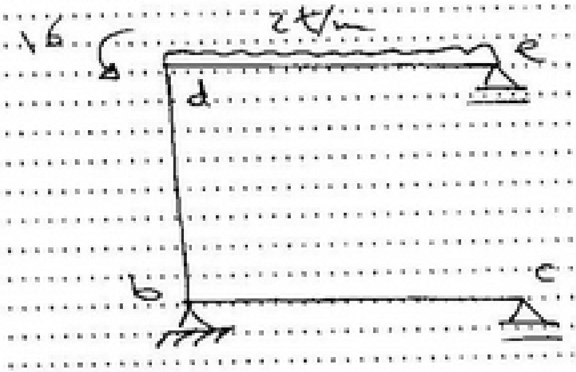
problem ②



الجزء (Ad) معروف العزم عليه (8×2 = 16) ↶



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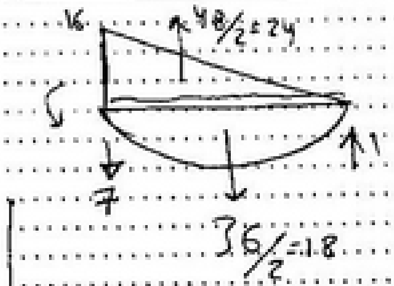
elastic Reaction



$R_b = 0.0$

$R_d = -7$

apply at (b)

$$M_c\left(\frac{6}{2}\right) + 2M_b\left(\frac{6}{2}+3\right) + M_d(3) = -6\times 0$$

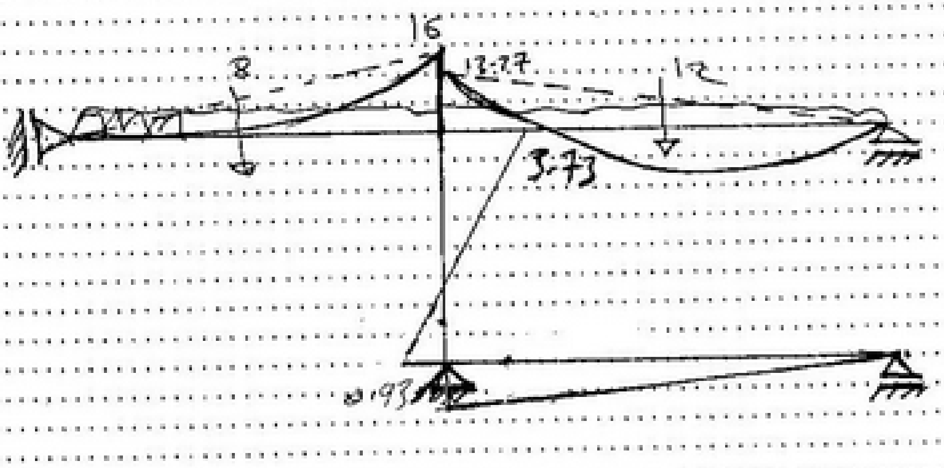
$$12M_b + 3M_d = 0.0 \longrightarrow (1)$$

apply at (d)

$$M_b(3) + 2M_d\left(3+\frac{6}{2}\right) + M_e\left(\frac{6}{2}\right) = -6\times -7$$

$$3M_b + 12M_d = +42 \longrightarrow (2)$$

$M_b = -0.93$ $\qquad$ $M_d = 3.73$



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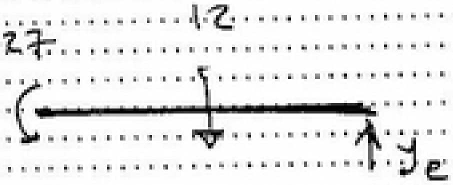
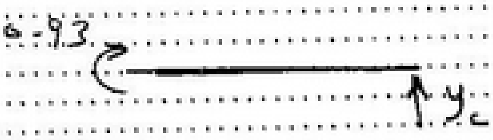


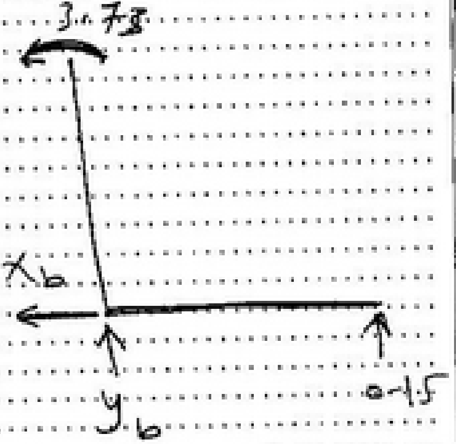
$$-12.27 = 6\,y_e - 12 \times 3$$

$$\boxed{y_e = 3.9}$$



$$0.93 = 6\,y_c$$

$$y_c = 0.15$$



$$3.73 = 3\,X_b - 0.15 \times 6$$

$$X_b = 1.55$$

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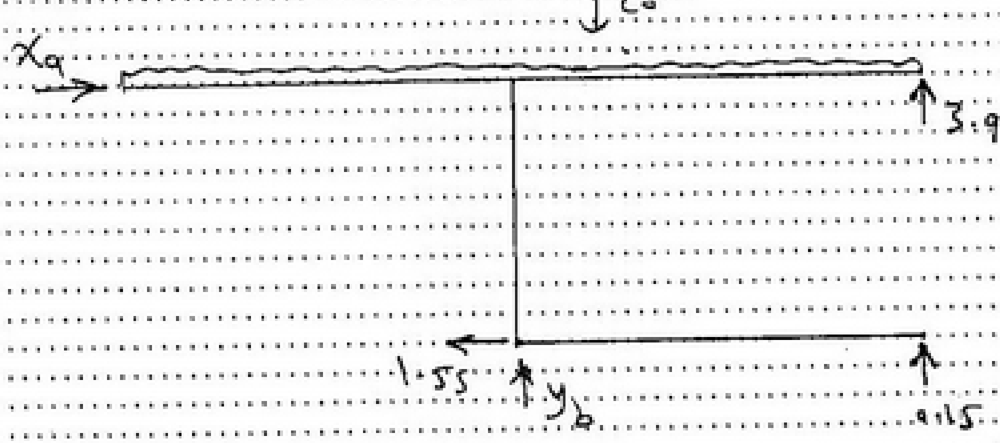
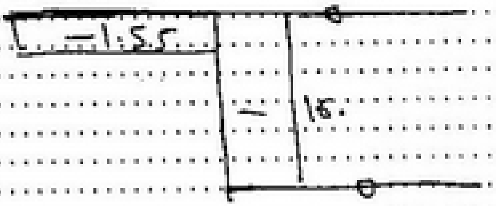


$\underline{\Sigma X = 0.0}$

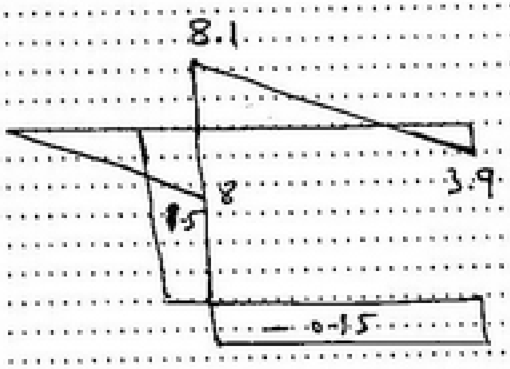
$X_a = 1.55$

$\underline{\Sigma Y = 0.0}$

$Y_b = 20 - 3.9 - 0.15 = 15.95$



N.F.D



S.F.D

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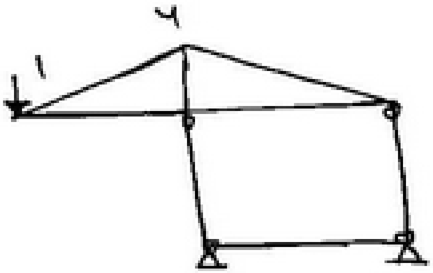
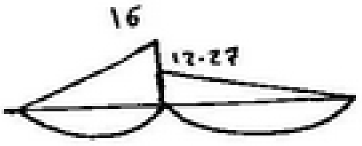


m_1



m_0

$$\delta_v = \int \frac{m_1 m_0}{EI} \cdot dl$$

$$= \frac{1}{10000} * \left[\frac{4*16*4}{3} + \frac{12.27*4*6}{3} - \frac{2*4^3}{12}*2 - \frac{2*6^3}{12}*2 \right)$$

$$= 0.009\,m$$

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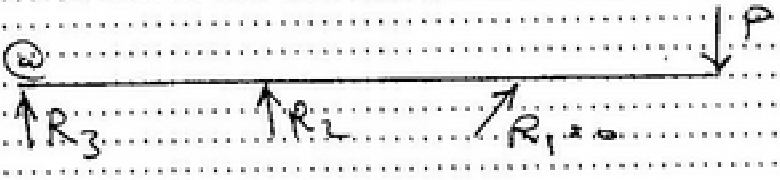
prob. ③



$R_1 = zero$ بسبب ترتيب الأعضاء لازم = صفر

$\Sigma M_a = zero$

$$R_2 \times 4 = P \times 16$$

$$R_2 = 4P$$

- $N = 4P$
- $L_b = 400\ cm$
- $i_{min} = \sqrt{9000/125} = 8.5$
- $\lambda = 400/8.5 = 47$
- $\sigma_{pb} = 1.1 - 0.00005(47)^2 = 0.99\ t/cm^2$
- $P_{pb} = 0.99 \times 125 = 123$

$$\frac{N}{A} \times \frac{\sigma_{pc}}{\sigma_{pb}} \leq \sigma_{pc}$$

$$\frac{N}{A} \leq \sigma_{pb} \Rightarrow \frac{4P}{125} \leq 0.99$$

$$P_{max} = 30.7\ ton$$

$$P_{cr} = \frac{\pi^2 E I}{L_b^2} = \checkmark \qquad n = \frac{P_{cr}}{P_{pb}}$$

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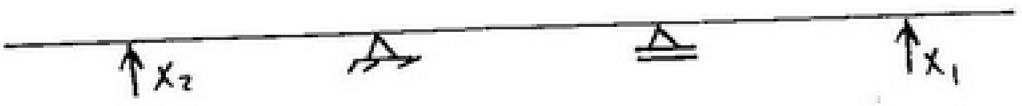
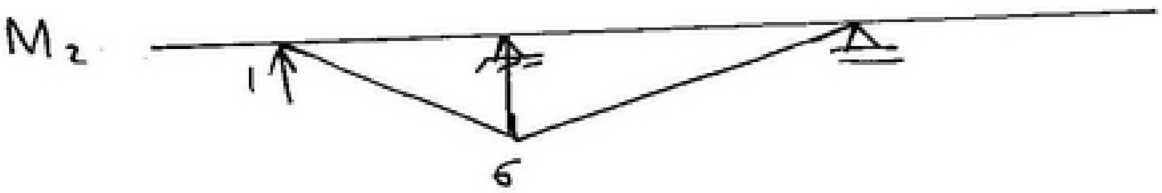
Prob4



1

2



3

$$\delta_{12} = \frac{1}{EI}\left[\frac{6*6*8}{6}\right] = \frac{48}{EI}$$

$$\delta_{11} = \frac{1}{EI}\left[\frac{6*6*6}{3} + \frac{6*6*8}{3}\right] = \frac{168}{EI}$$

$$\delta_{22} = \delta_{11} = \frac{168}{EI}$$

(4) for y_d

$$\frac{168}{EI} \cdot X_1 + \frac{48}{EI} \cdot X_2 = 1.0$$

$$\frac{48}{EI} \cdot X_1 + \frac{168}{EI} \cdot X_2 = 0.0$$

$\therefore$ $X_1 = \frac{EI}{154}$ assume $EI = 540$

$X_2 = -\frac{EI}{540}$

$X_1 = 3.5$
$X_2 = -1$

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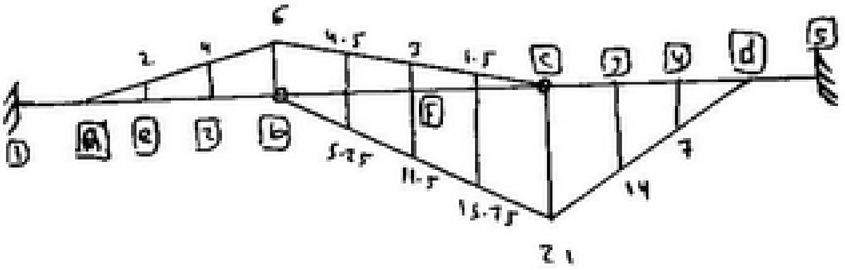
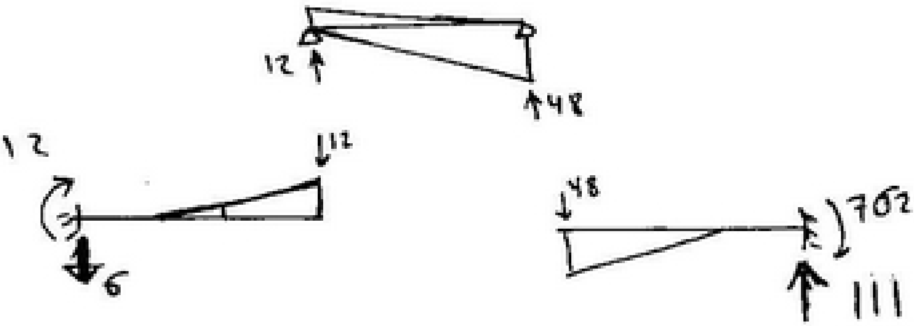
$m_f = +3.5\, M_1$

$- M_2$





$\delta_1 = \frac{1}{540} * (12) = 0.02$

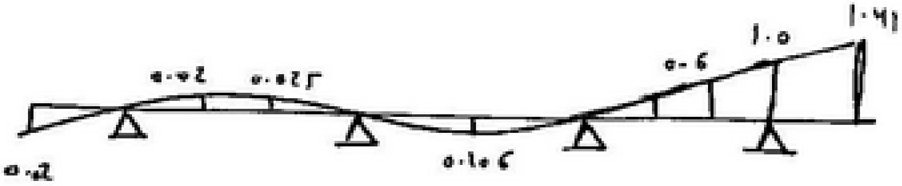
$\delta_a = \frac{1}{540} * (0) = 0.0$

$\delta_e = \frac{1}{540} (-10.67) = -0.02$

$\delta_2 = -0.025$

$\delta_b = 0.0$

$\delta_f = 0.106$



I L Y_d

$\delta_c = 0.0$

$\delta_4 = -0.6$

$\delta_d = -1.0$

$\delta_5 = -1.41$

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titanic_ship1912@yahoo.com

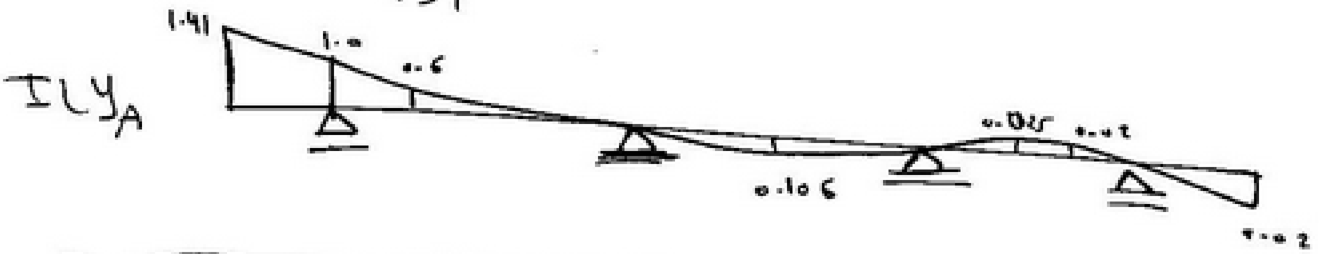
5 For y_A

$$168 \cdot X_1 + 48 \cdot X_2 = 0.0$$

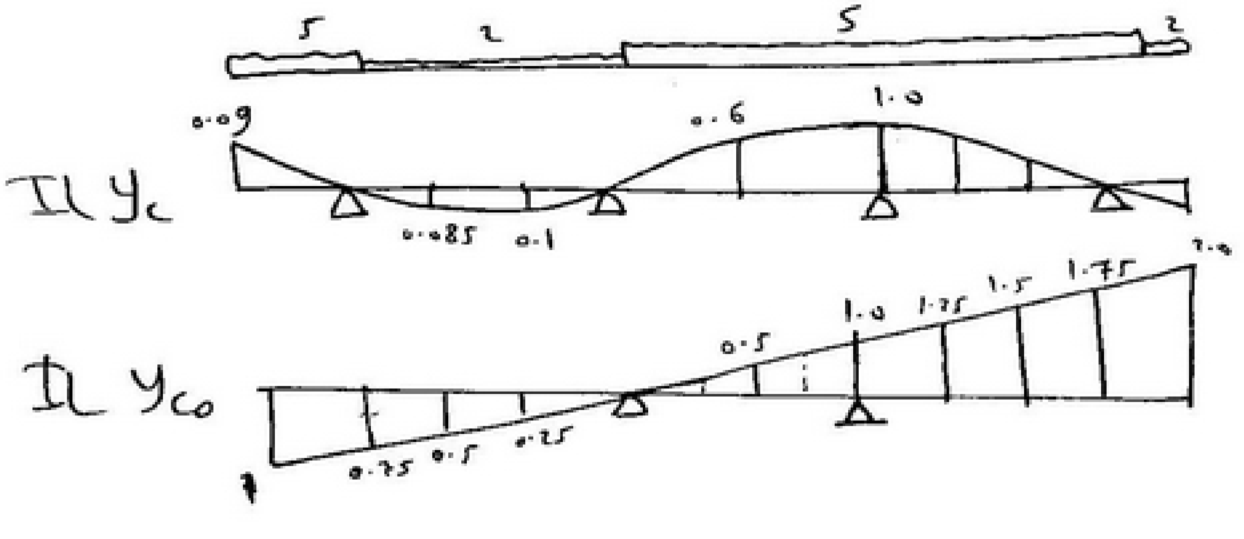
$$48 \cdot X_1 + 168 \cdot X_2 = EI$$

$$X_1 = -\frac{EI}{540}$$

$$X_2 = \frac{EI}{154}$$



$$ILY_c = ILY_{co} + (0.75)\, ILY_A + (-1.75)\, ILY_d$$



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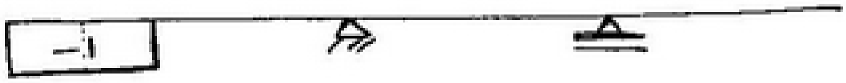
ILMA

ILQE

Q_{e_0}

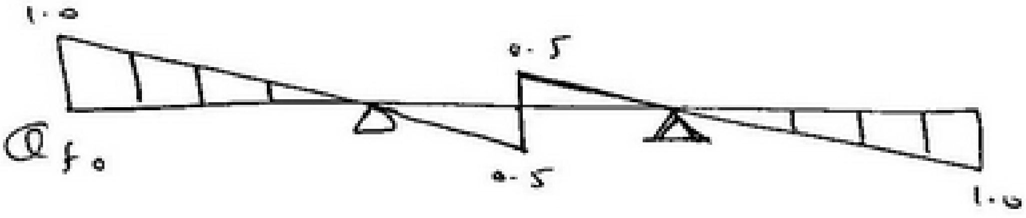


$IlQ_e = IlQ_{e_0} + y_A$

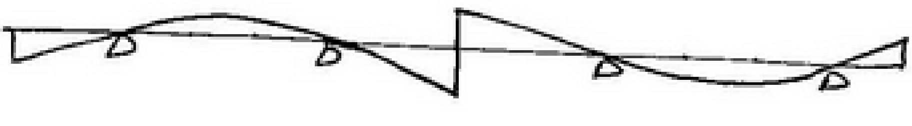
Q_e

ILQf

Q_{f_0}



IlQ_f



$IlQ_f = IlQ_{f_0} - 1.75\ y_A + 0.75\ y_b$

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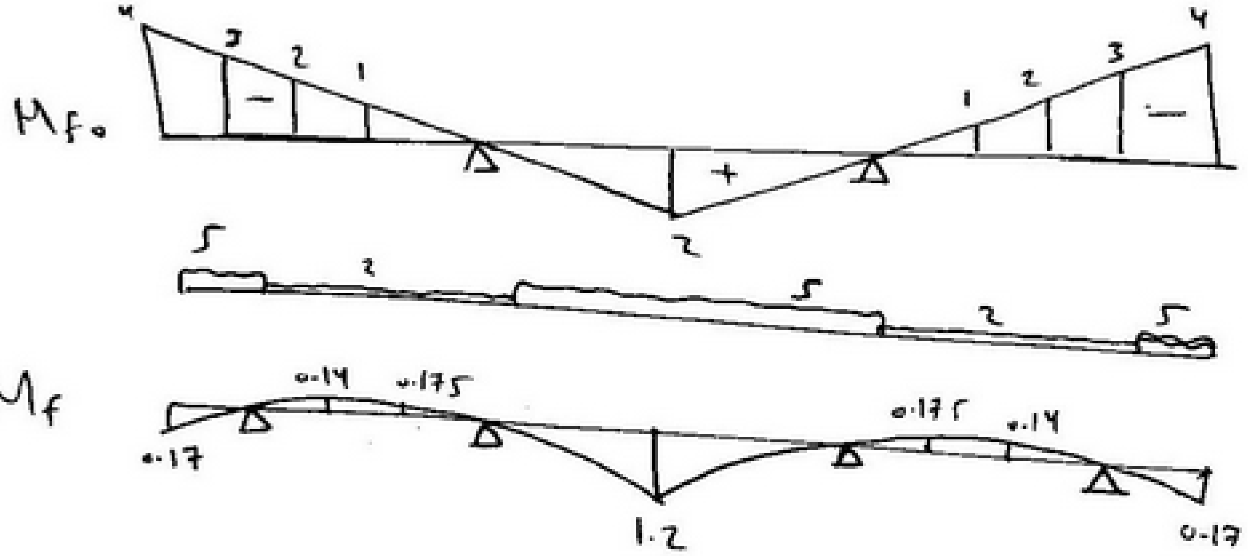
$$\underline{ILM_f} = ILM_{fo} + 3\ ILy_A + 3\ ILy_d$$



<u>for max</u> $y_c = -2 * (0.6) + 5 * (9.42)$
$= 45.9$ ton

<u>for max</u> $M_f = -2 * (1.2)$
$+ 5 * (3.54) = 15.3$ t.m

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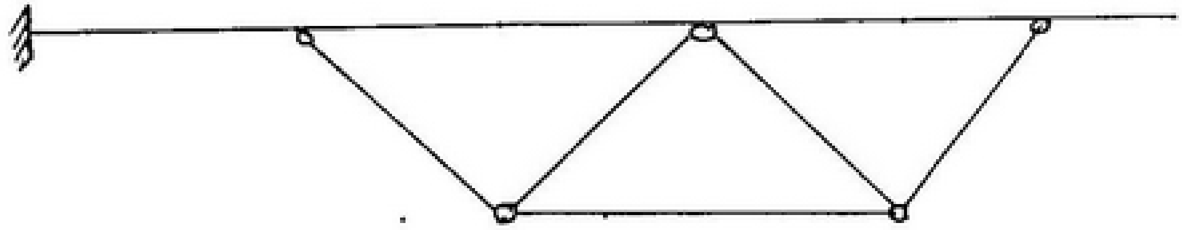
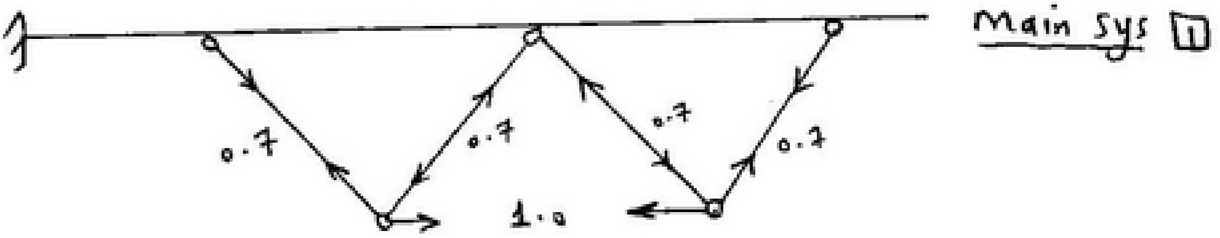
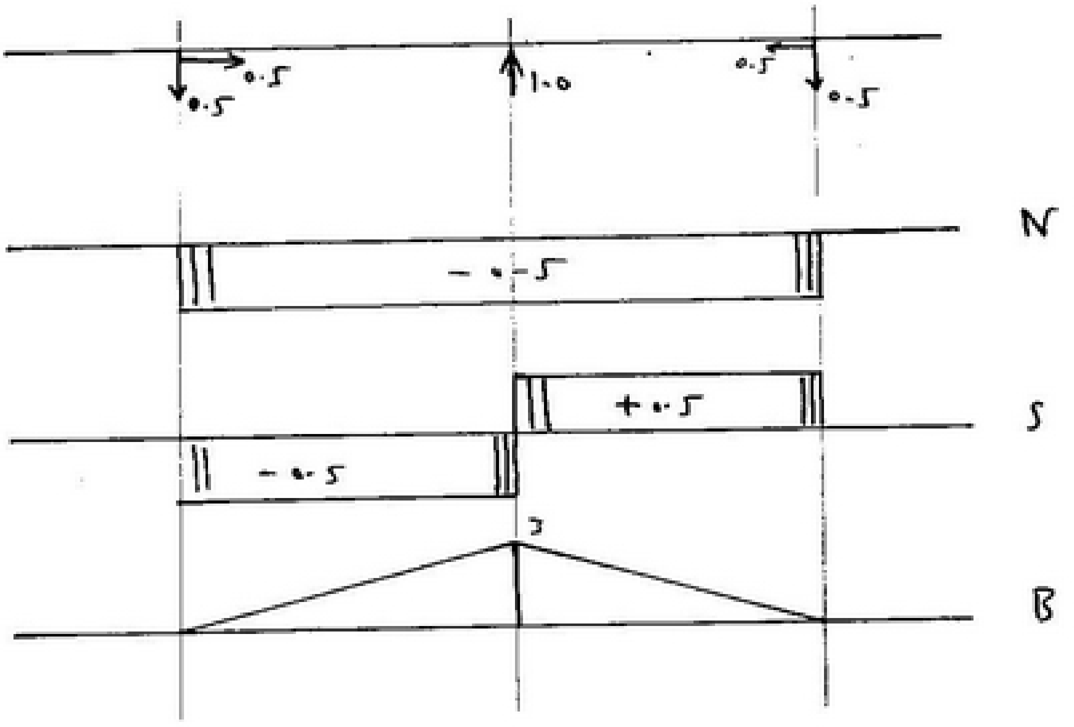
probs







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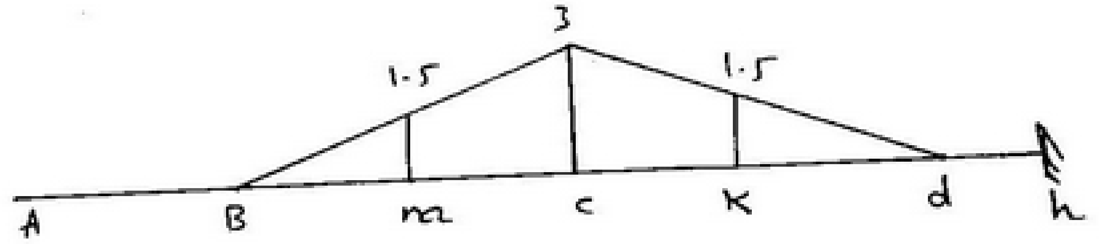
$$\delta_{11} = \frac{1}{20000} * \left[\frac{3*3*6}{3} * 2\right] + \frac{1}{80000} * \left[0.5^2 * 12\right] + \frac{1}{40000} * \left[4 * 0.7^2 * 4.25 + 1*6\right]$$

$$= 0.002$$

$$X_1 = \frac{1}{\delta_{11}} = 500$$

$$\delta_i = \frac{500}{20000} * M_i = 0.025\, M_i$$



$\delta_a = 0.0$

$\delta_b = 0.0$

$\delta_M = 0.025 * (0.5*1.5*3*1) = 0.056$

$\delta_c = 0.025 * (0.5*3*6*2) = 0.45$

$\delta_K = 0.025 * (9*5 + 4.5*1.5 + 0.5*1.5*3*2) = 1.4$

$\delta_d = 0.025 * (9*8 + 9*4) = 2.7$

$\delta_h = 0.025 * [9*10 + 9*6] = 3.6$

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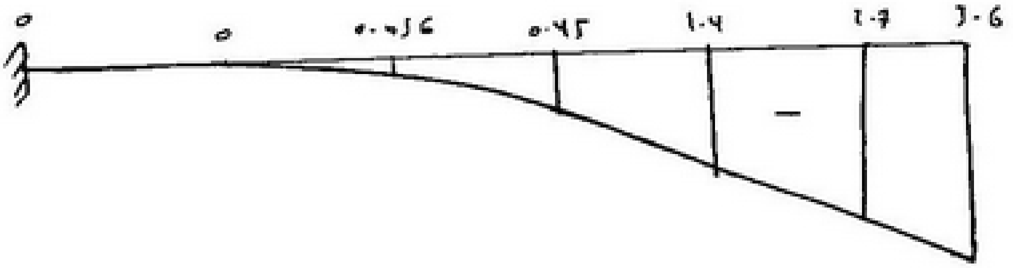
ILX1



Factors

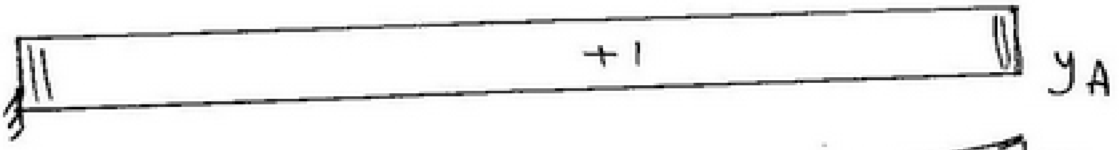
$y_a = 0.0$

$M_b = 0.0$

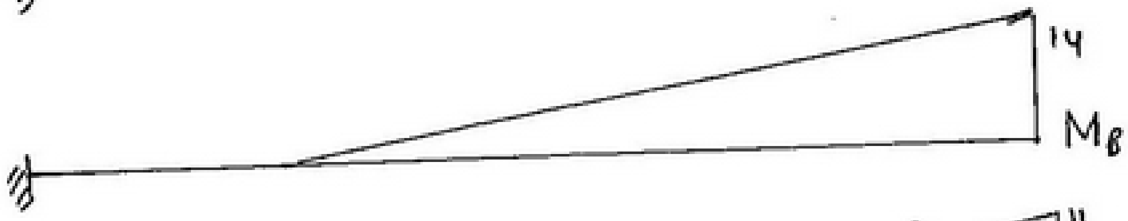
$Q_m = -0.5$

$M_m = -1.5$

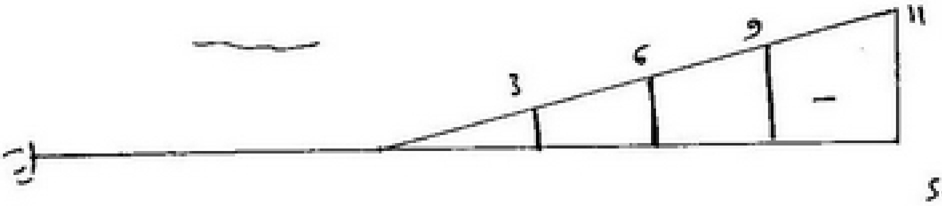
(1)



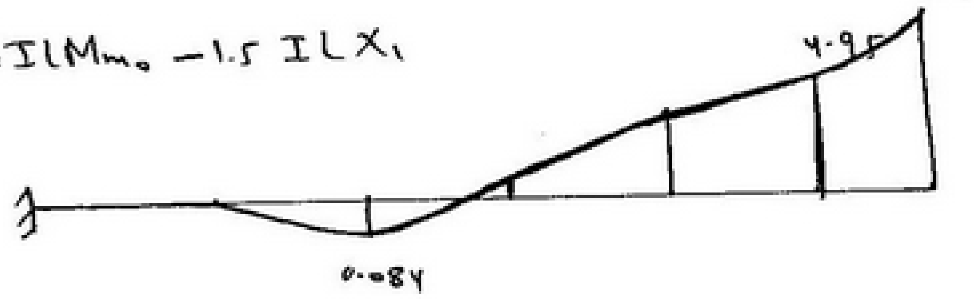
(2)



(3) ILM_{m_0}



$ILM_m = ILM_{m_0} - 1.5\ ILX_1$



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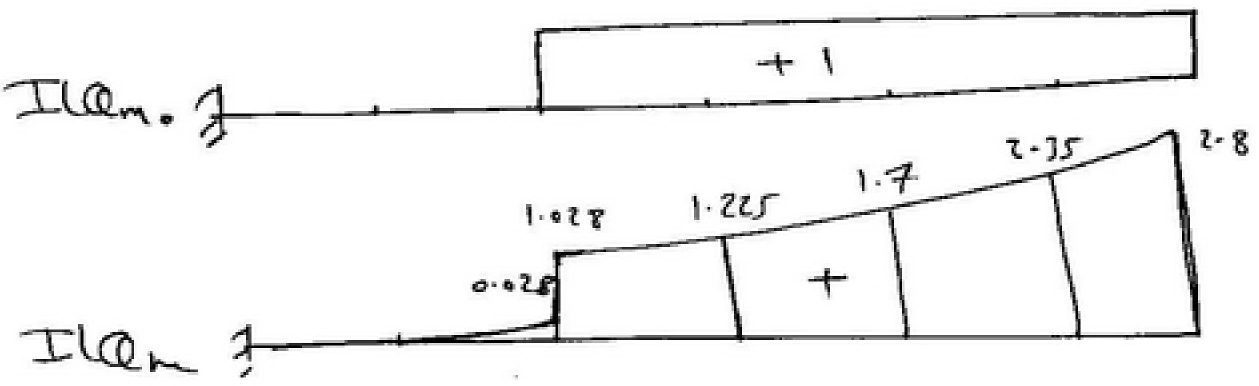
$IL\,Q_m = IL\,Q_{m_0} - 0.5\, IL\, X_1$



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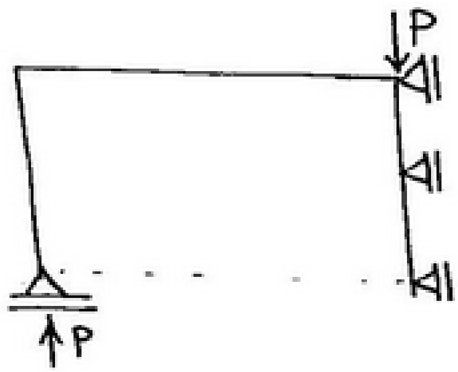
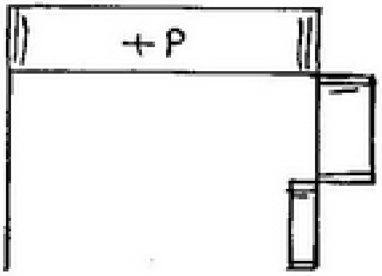
prob(6)

(a)

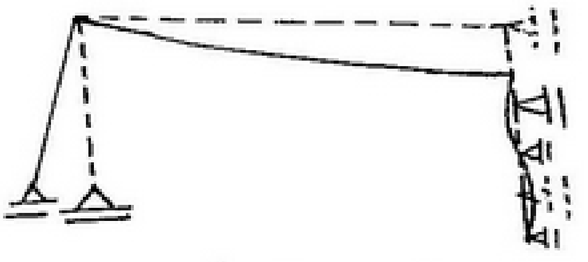


B.M.D



S.F.D

N.F.D



elastic Curve

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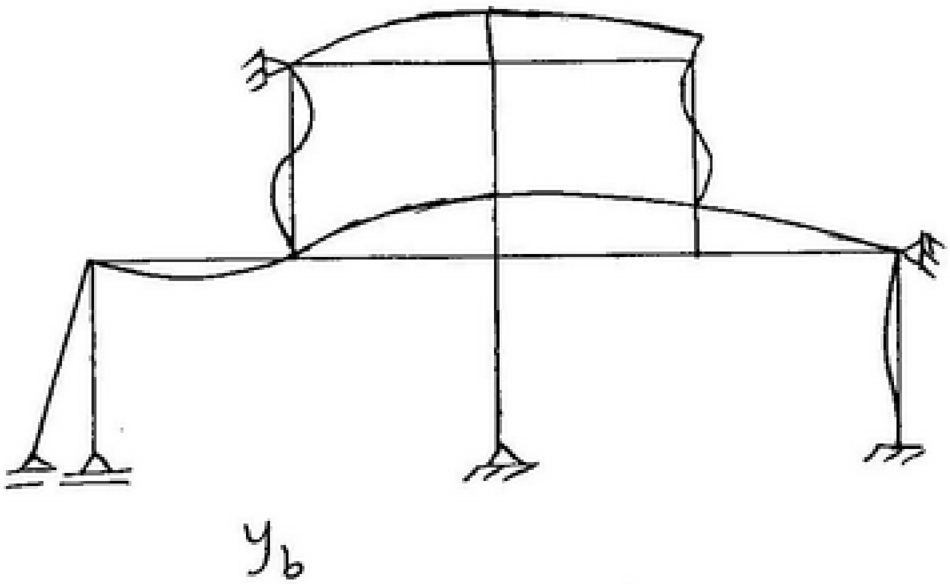
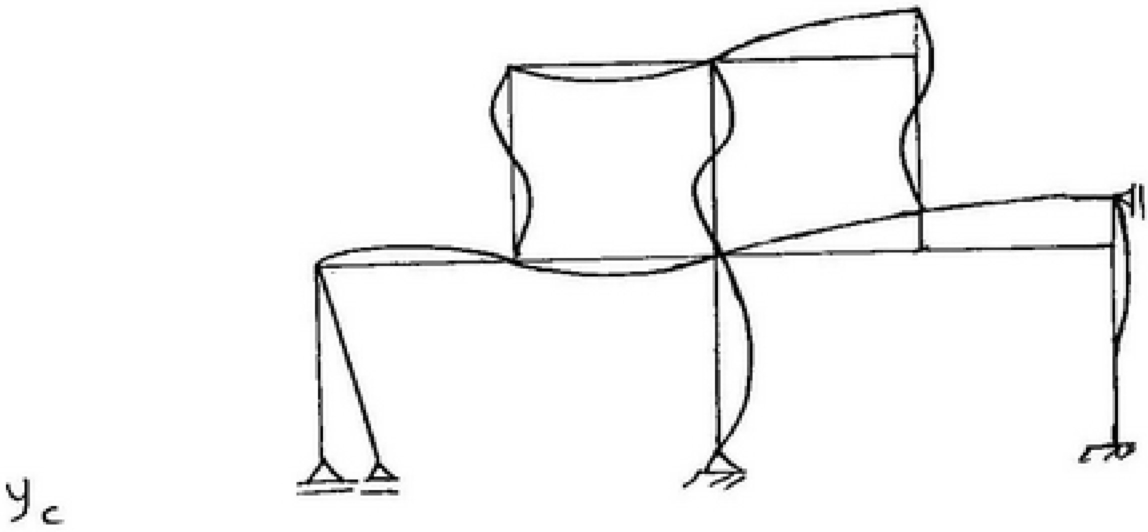
(b)





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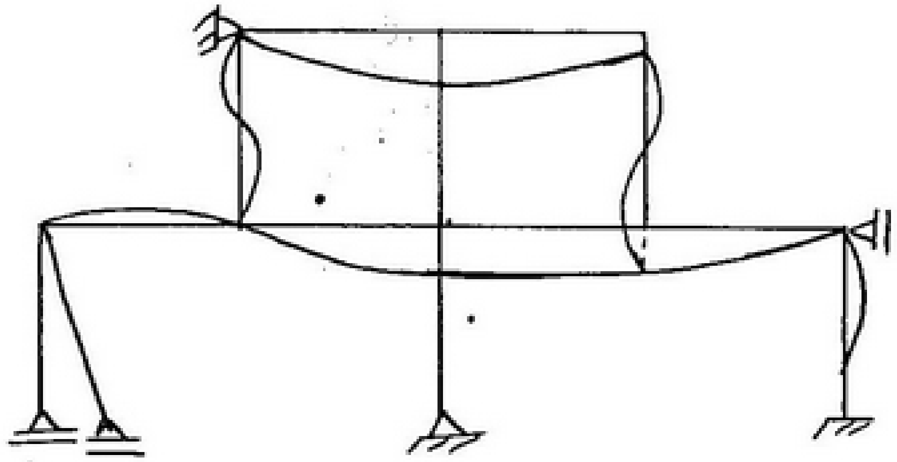
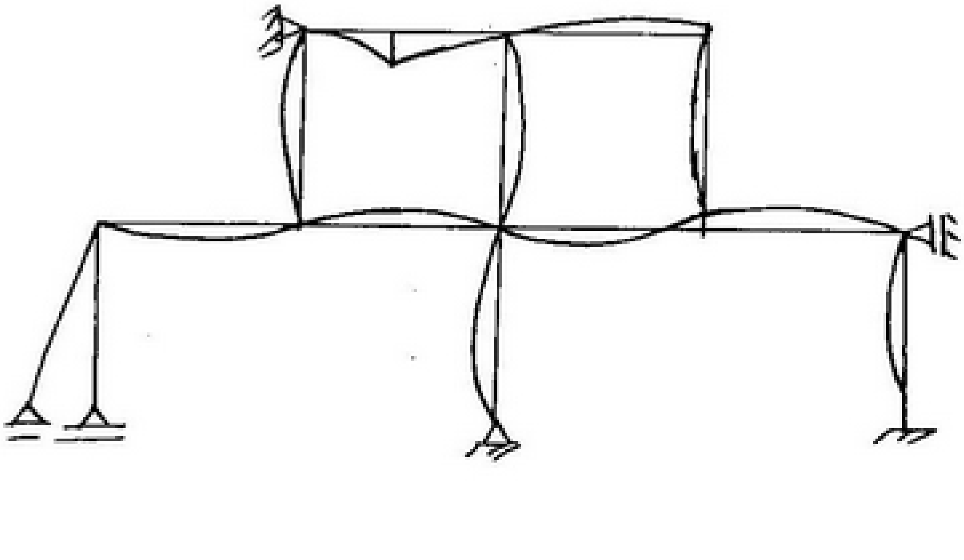
$N_{R} = -y_b$



$N_K \longrightarrow$ Zero

M_m



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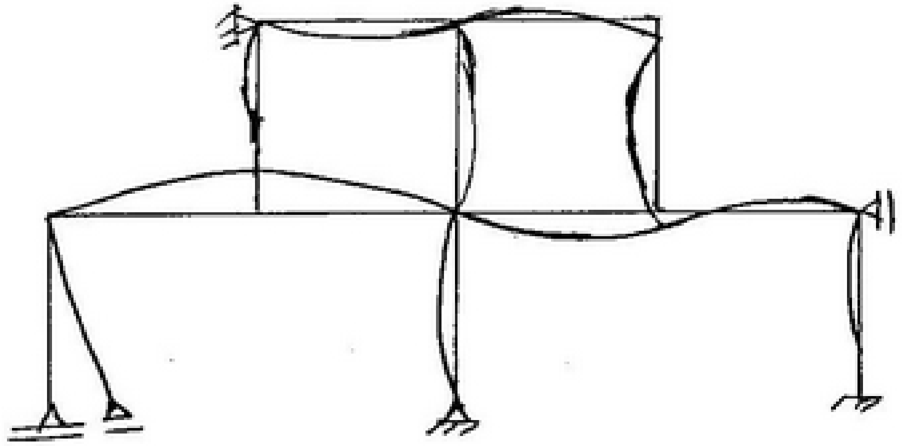
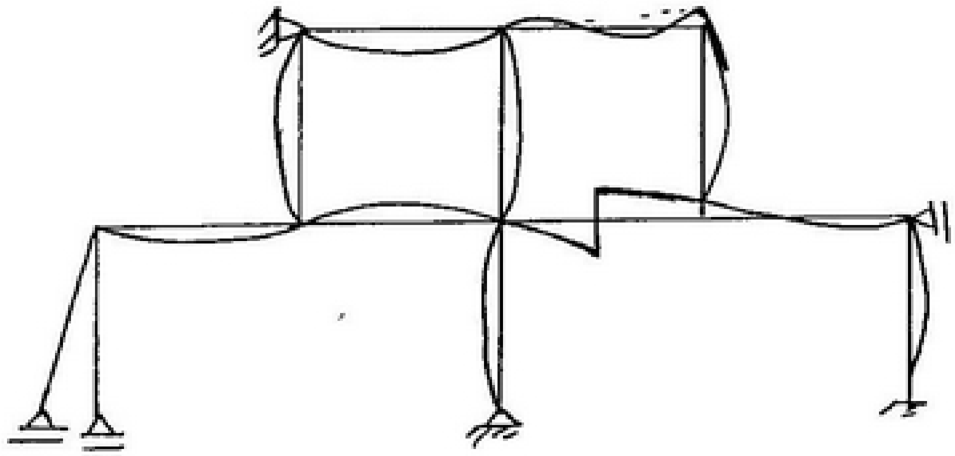
N_N



Q_L



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Course Name :	Structural Mechanics (2)	Zagazig University Faculty of Engineering	Final Exam	
Course Code :			Date	: 20-5
Level :	Second Year Civil		Time	: 3 Hours
Department :	Structural Engineering		No. of pages	: 2
Term No. :	2		No. of Questions	: 6

SOLVE AS YOU CAN (Full mark from 60)

Problem No. (1) *(10 marks)*

For the columns shown in figure (1), derive the formula of buckling length for each case.

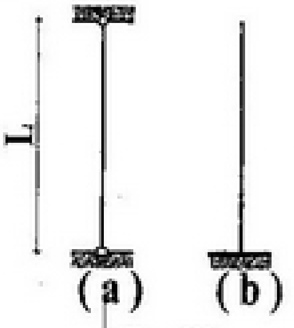

Fig. (1)

Problem No. (2) *(10 marks)*

For the shown strut, if the beam is restricted in plane and out of plane as shown in figure (2), Find the max. value of Δt which make the strut still stable.

Cross Section is (SIB NO. 32)

Steel 52 $\alpha = 1.2\times10^{-5}$

$E = 2000$ t/ cm^2 , $A = 77.7$ cm^2,

$I_x = 12150$ cm^4 & $I_y = 555$ cm^4

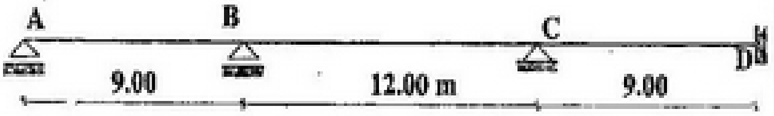

Fig. (2)

Problem No. (3) *(11 marks)*

Figure (3) shows a column (Steel 37) with height of 5.0 m. and has two hinged at the ends. It carries lateral and vertical loads as shown. If the cross-section of the column is circular with diameter 20 cm, find the maximum horizontal permissible load F and the corresponding maximum deflection at the med-height of the column. Consider the moment due to vertical force.

$E = 2000$ t/ cm^2 , $\sigma_{pc} = 1.1$ t/cm^2

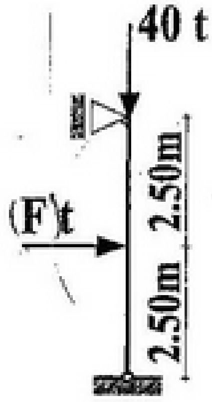

Fig. (3)

Problem No. (4) *(11 marks)*

For the beam shown in Fig. (4), calculate and draw the influence lines for Y_C, M_A, Q_E, Q_F, Q_G and M_B. Also, find the maximum values for Y_C and M_B due to 2t/m dead load and 3 t/m live load

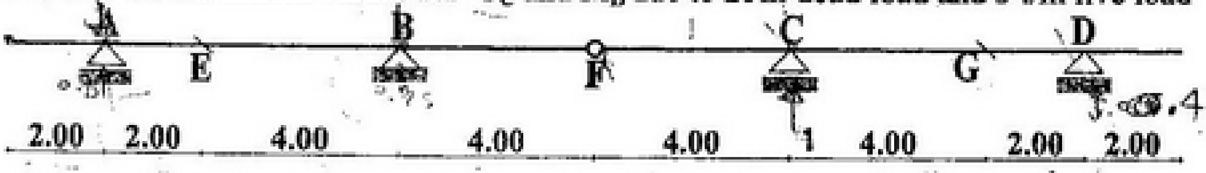

Fig. (4)

اقلب الصفحة من فضلك

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Problem No. (5) *(12 marks)*

For the shown statically indeterminate trussed beam (Fig. 5), introduce the influence lines for Y_B, M_G, N_{FH}, N_{FE} and M_E.

EI_{frame} = 20000 t.m² **EA_{Frame} = 80000 t** **EA_{links} = 40000 t**

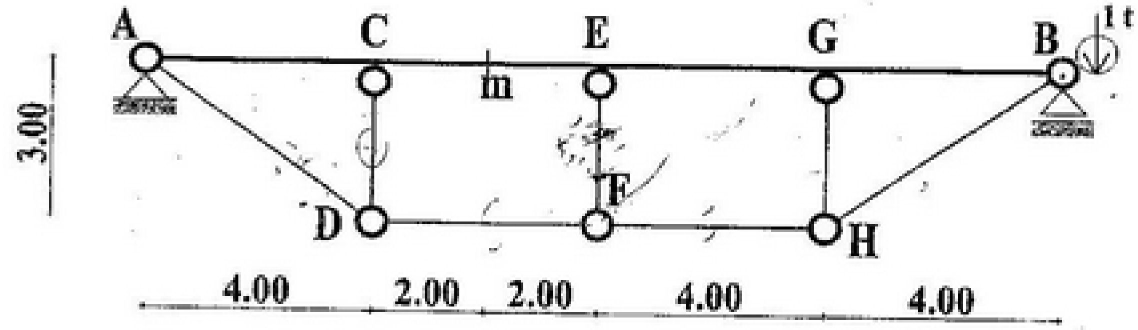

Fig. (5)

Problem No. (6) *(12 marks)*

a) For the structure shown in figure (6-a), without calculations, sketch the elastic curve, the bending moment diagram and the main steel reinforcement.

b) For the structure shown in figure (6-b), without calculations, sketch the influence lines for Y_C, X_B, M_A, Q_F and N_G

c) For the beam shown in figure (6-c) sketch the absolute bending moment

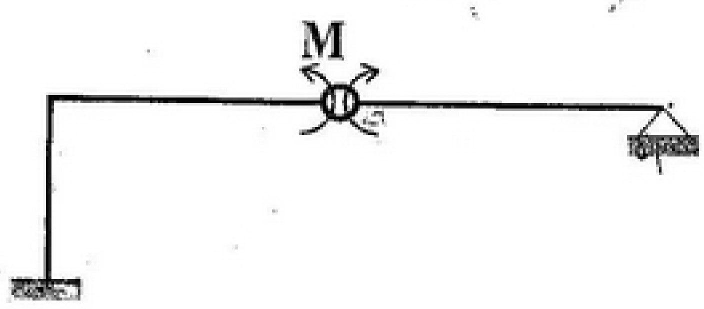

Fig. (6-a)

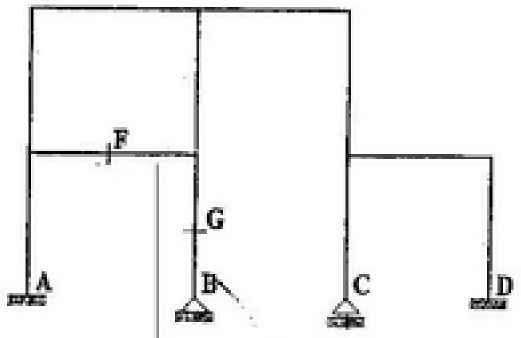

Fig. (6-b)

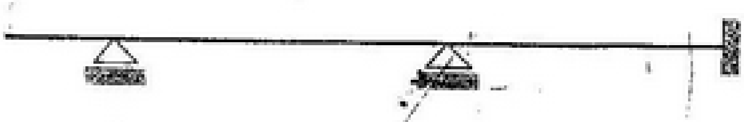

Fig. (6-c)

Prof. Dr. Sayed Abd-El Salam

Assist.Prof. Osman Shallan *Dr. Hanaa Elsayed*

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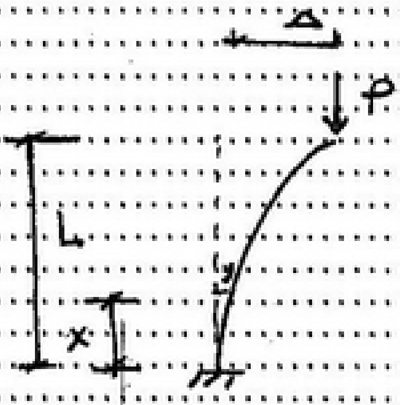
prob ①



$M = -P(\Delta - y)$

$y'' = +\frac{P}{EI}(\Delta - y)$

assume $c^2 = \frac{P}{EI}$

$y'' = c^2\Delta - c^2 y$

$y'' + c^2 y - c^2\Delta = 0.0$

$\therefore$ $\boxed{y = C_1 \cos cx + C_2 \sin cx + \Delta}$

B.C. at $x = 0.0 \longrightarrow y = 0.0 \longrightarrow C_1 = -\Delta$

at $x = 0.0 \longrightarrow y' = 0.0 \longrightarrow C_2 = 0.0$

at $x = L \longrightarrow y = \Delta \longrightarrow \cos cL = 0$

$cL = n\frac{\pi}{2}$

$$\frac{P}{EI} = \frac{n^2\pi^2}{4L^2}$$

$$P_{cr} = \frac{n^2\pi^2 EI}{(2L)^2} = \frac{n^2\pi^2 EI}{L_b^2}$$

$$\boxed{L_b = 2L}$$

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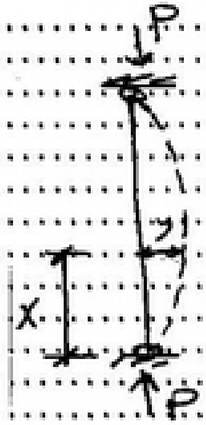

$$M = P \cdot y$$

$$\ddot{y} = -\frac{P}{EI} y$$

$$\ddot{y} + C^2 y = 0.0$$

$$\boxed{y = C_1 \cos Cx + C_2 \sin Cx}$$

at $X = 0 \longrightarrow y = 0.0 \longrightarrow C_1 = 0.0$

at $X = L \longrightarrow y = 0.0 \longrightarrow C_2 \sin CL = 0.0$

$$\sin CL = 0.0$$

$$CL = n\pi$$

$$\frac{P}{EI} = \frac{n^2 \pi^2}{L^2}$$

$$P = \frac{n^2 \pi^2 EI}{L^2} = \frac{n^2 \pi^2 EI}{L_b^2}$$

$$\boxed{L_b = L}$$

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prob. ②

$$\Delta t \leq \frac{\pi^2 * I_{min}}{L_b^2 * \alpha * A}$$

$$L_b = 0.7 * 9 = 6.3 = 630 \, cm$$

$$\therefore \Delta t_{max} \leq \frac{\pi^2 * 555}{630^2 * 1.2 \times 10^{-5} * 77.7}$$

$$\Delta T_{max} = 14.8^\circ$$

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raed

prob (3)

$$A = \frac{\pi}{4}(20)^2 = 314\ cm^2$$

$$I_x = I_y = \frac{\pi}{64}(20)^4 = 7854\ cm^4$$

$$\sigma = \frac{P}{A} + \frac{M}{I}y$$

$$\frac{40}{314} + \frac{M}{7854} * 10 \leq 1.1$$

$$M = 764\ t.cm$$

$$M = \frac{F}{2c}\tan\left(\frac{cL}{2}\right)$$

$$c = \sqrt{\frac{P}{EI}} = \sqrt{\frac{40}{2000 * 7854}} = 1.6 * 10^{-3}$$

$$\therefore 764 = \frac{F}{2 * 1.6 * 10^{-3}}\tan\left(\frac{1.6 * 10^{-3} * 500}{2}\right)$$

$$F = 5.8\ ton$$ (ok)

$$y_o = \frac{F}{2Pc}\tan\left(\frac{cL}{2}\right) - \frac{HL}{4P} = 1.03\ cm$$

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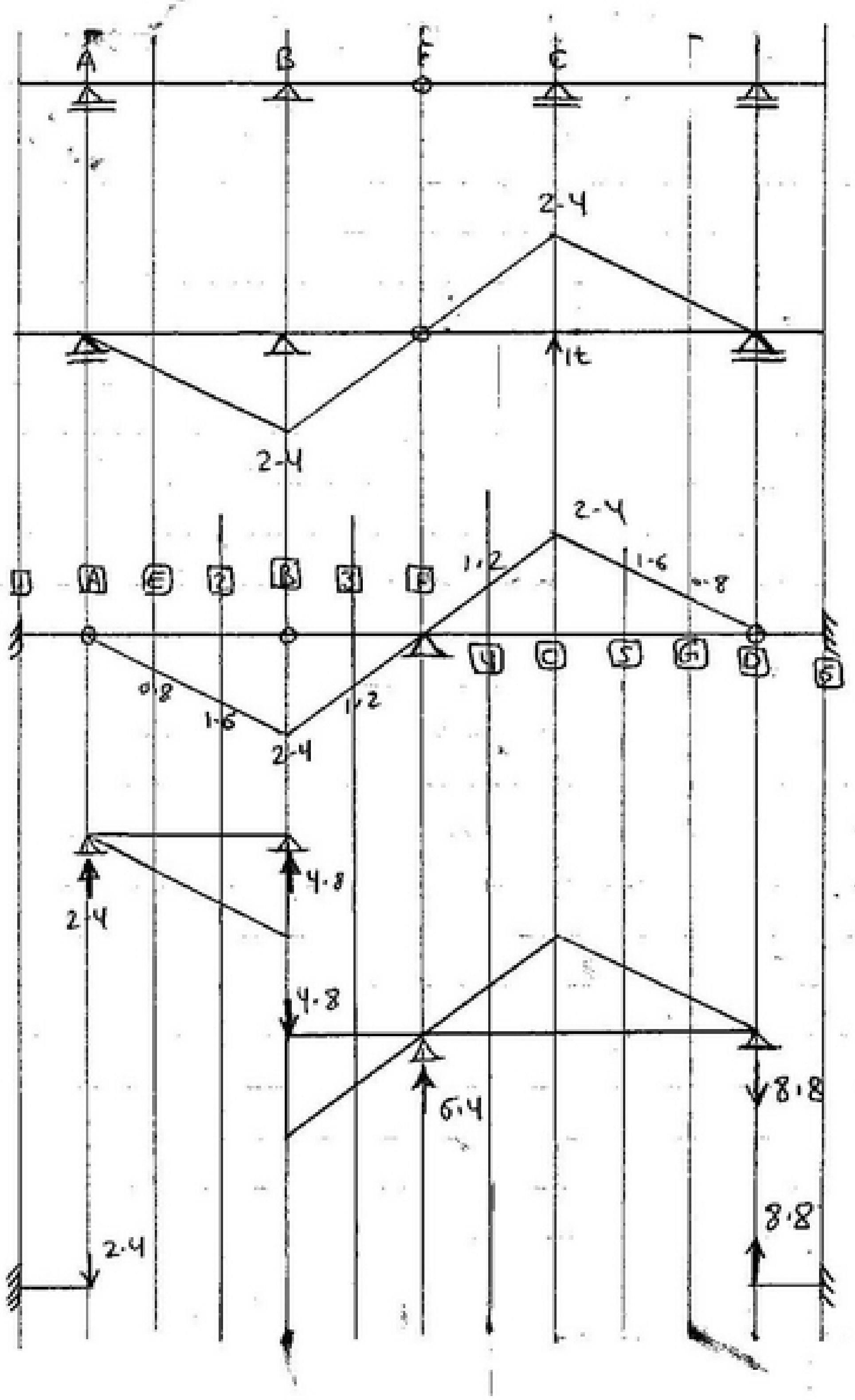
prob (9)



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$M_1 = -2.4 * 2 = -4.8$

$M_A = 0.0$

$M_E = 2.4 * 2 - 0.5 * 0.8 * 2 * 2/3 = 4.26$

$M_2 = 2.4 * 4 - 0.5 * 1.6 * 4 * 4/3 = 5.33$

$M_B = 0.0$

$M_3 = -4.8 * 2 - 1.2 * 2 * 1 - 1/2 * 1.2 * 2 * \frac{4}{3} = -13.6$

$M_F = -4.8 * 4 - 1/2 * 2.4 * 4 * 8/3 = -32$

$M_4 = -4.8 * 6 - 1/2 * 2.4 * 4 * [2 + 2/3 * 4]$

$+ 6.4 * 2 + 1/2 * 1.2 * 2 * 2/3 = -37.6$

$M_C = -8.8 * 6 + 1/2 * 2.4 * 6 * 2 = -38.4$

$M_5 = -8.8 * 4 + 1/2 * 1.6 * 4 * 4/3 = -30.9$

$M_G = -8.8 * 2 + 1/2 * 0.8 * 2 * 2/3 = -17$

$M_D = 0.0$

$M_6 = 8.8 * 2 = 17.6$

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$\therefore \quad \delta_1 = 0.125$

$\delta_A = 0.0$

$\delta_E = -0.11$

$\delta_2 = -0.139$

$\delta_B = 0.0$

$\delta_3 = 0.354$

$\delta_F = 0.833$

$\delta_4 = 0.979$

$\delta_C = 1.0$

$\delta_5 = 0.805$

$\delta_G = 0.44$

$\delta_d = 0.0$

$\delta_E = -0.453$

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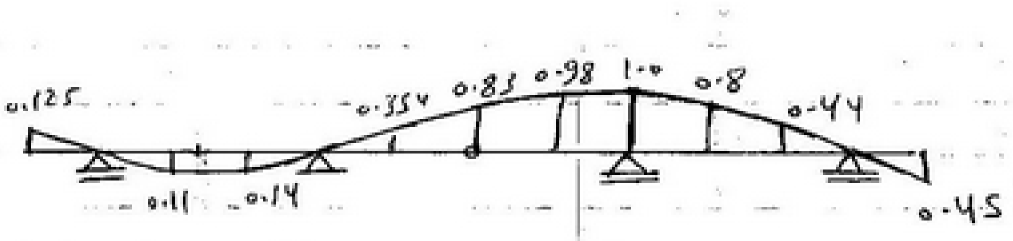
$IL\,y_c$



ILM_A

$IL\,Q_E$

factor = -0.4

$$IlQ_E = IlQ_{E_0} + 0.4\, Ily_c$$

IlQ_E

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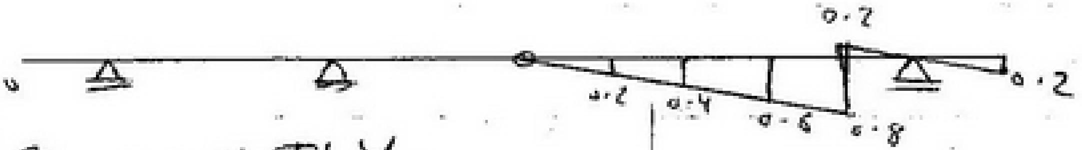
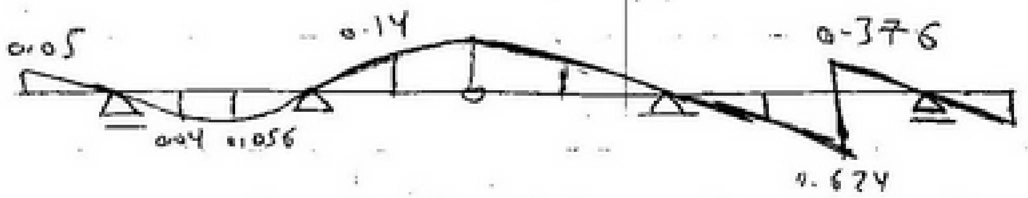
IL Q_G

$IL\,Q_{G_0}$



$$IL\,Q_G = IL\,Q_{G_0} + 0.4\, IL\,Y_C$$

$IL\,Q_G$

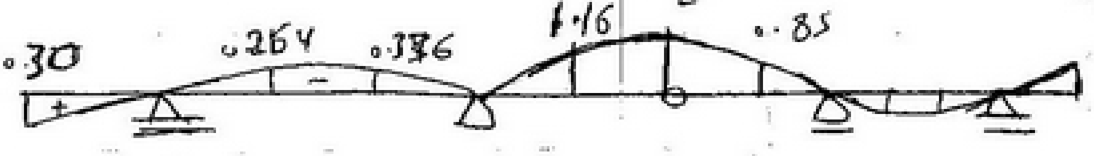


IL M_B

$IL\,M_{B_0}$

$$IL\,M_B = IL\,M_{B_0} + 2.4\, IL\,Y_C$$

$IL\,M_B$



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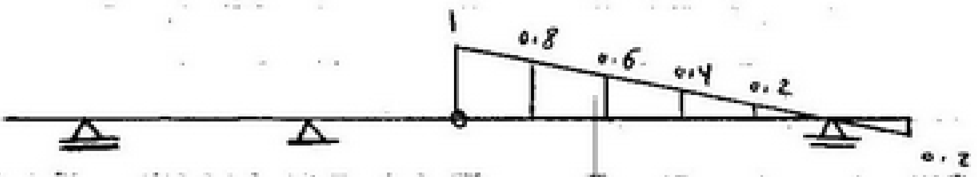
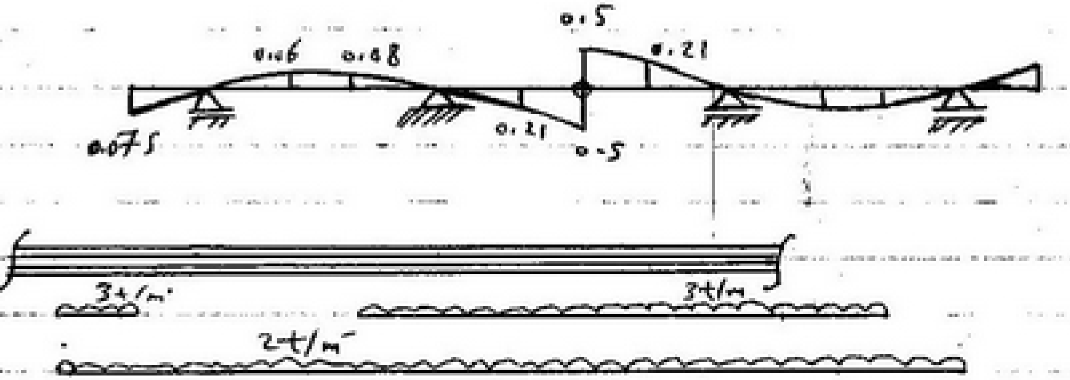
ILQf

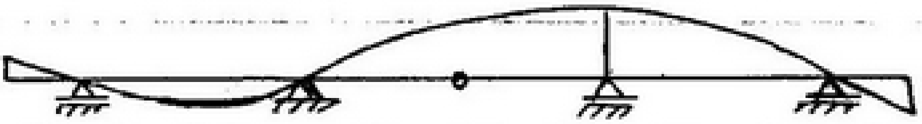
ILQf₀



$$ILQ_f = ILQ_{f_0} - 0.6\ ILy_c$$



ILy_c



$$y_{c\,max} = 2 * [\tfrac{1}{2} * 0.125 * 2 - \tfrac{2}{3} * 0.13 * 6 + \tfrac{2}{3} * 1 * 14 - \tfrac{1}{2} * 0.4 * 2]$$

$$+ 3 * [\tfrac{1}{2} * 0.125 * 2 + \tfrac{2}{3} * 1 * 14]$$

$$= 45.35 \text{ ton.}$$

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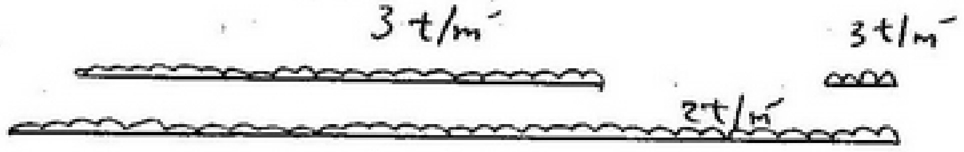
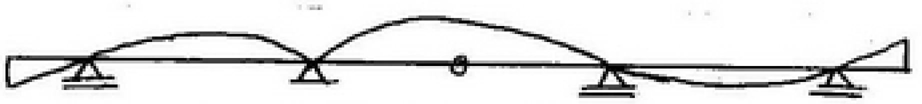


ILM$_B$



$$M_{B_{max}} = 2*[-\tfrac{1}{2}*0.3*2 + \tfrac{2}{3}*0.3*6 + \tfrac{2}{3}*2*8 - 0.3*\tfrac{2}{3}*6 + \tfrac{1}{2}*0.25*2]$$

$$+3*[\tfrac{2}{3}*0.3*6 + \tfrac{2}{3}*2*8 + \tfrac{1}{2}*0.25*2]$$

$$= 57.6 \ t.m.$$

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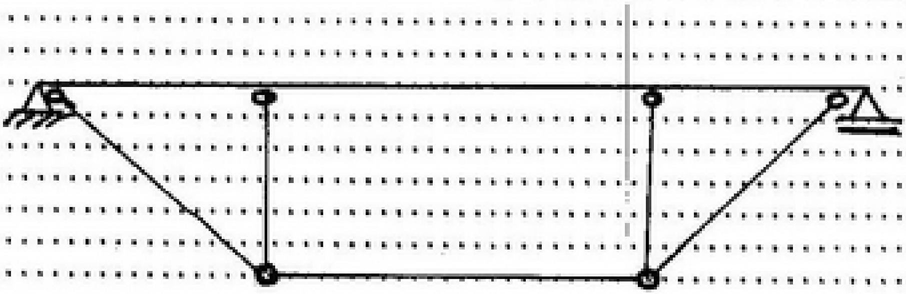
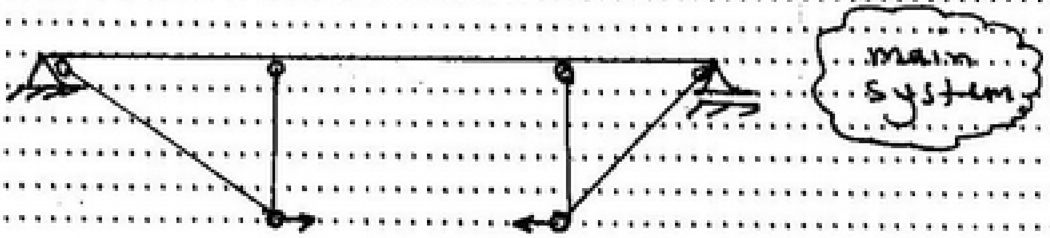
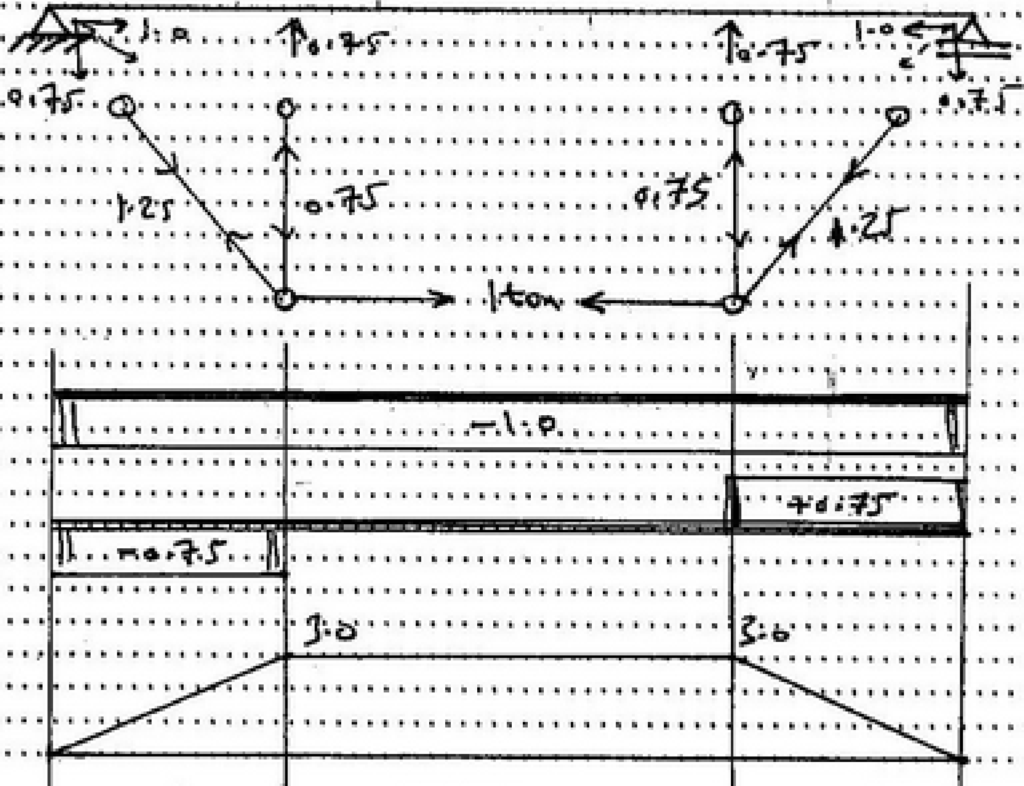
prob (5).







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Factors.

$y_B = \text{Zero}$

$N_{Fe} = 0.0$

$M_g = -3.0$

$M_e = -3.0$

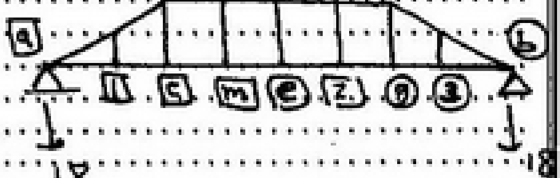
$$\delta_{11} = \frac{1}{40000}\left[1*8 + 0.75^2*3*2 + 1.25^2*5*2\right] + \frac{1}{80000}*\left[1*16\right]$$

$$+ \frac{1}{20000}*\left[\frac{3*3*4}{3}*2 + 3*3*8\right]$$

$$= 5.675*10^{-3}$$

$$X_1 = \frac{1}{\delta_{11}} = 176 \text{ ton}$$

$$\delta_i = \frac{175}{20000}*\left[M_i\right]$$



$\delta_a = 0.0$

$\delta_1 = -0.3$

$\delta_c = -0.56$

$\delta_m = -0.72$

$\delta_e = -0.75$

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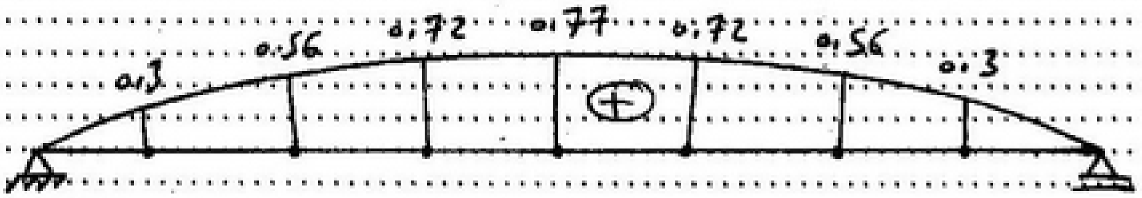
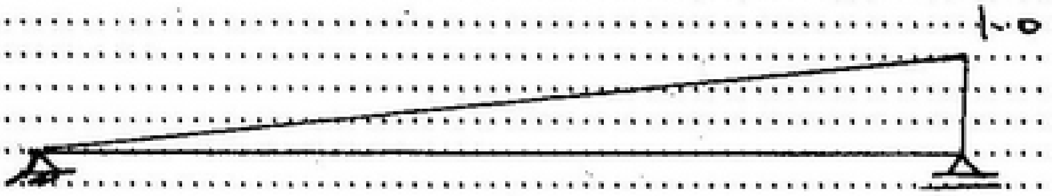
I.L N_{fh}



—

$IL\ y_b = IL\ y_{b_o} + 0$

IL y_{b_o}



—

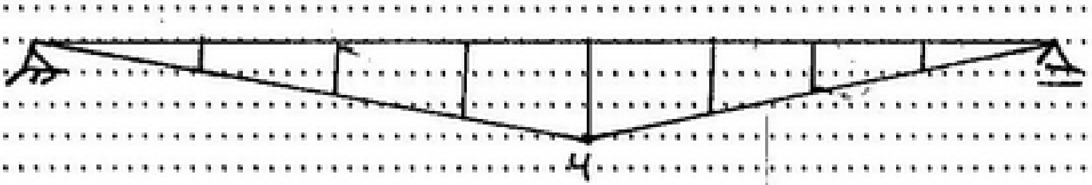
$IL\ N_{fc} = zero$

0

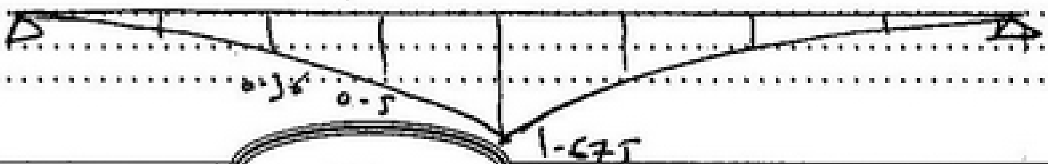
—

$IL\ M_e = IL\ M_{e_o} + (-3)\ IL\ N_{fh}$

IL M_{e_o}



IL M_e



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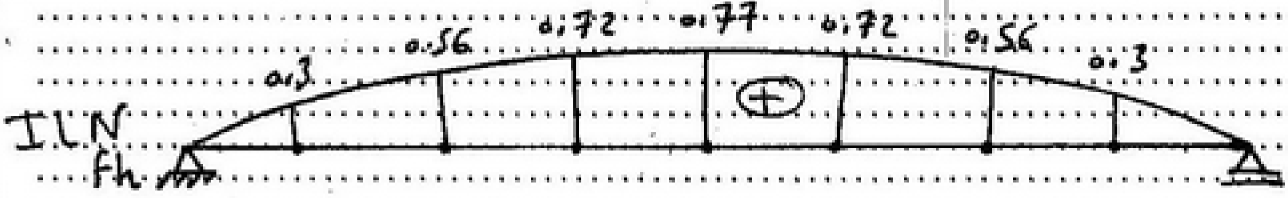
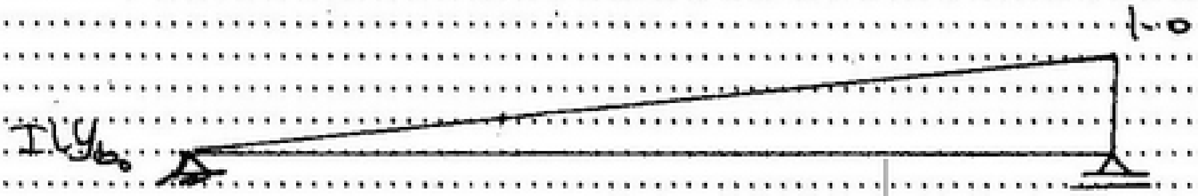


—

$IL\,y_b = IL\,y_{b_0} + 0$

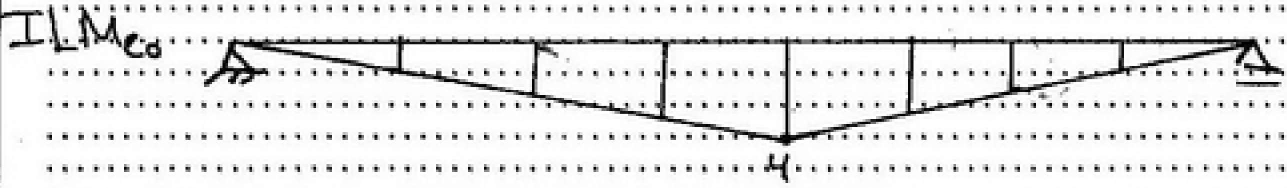


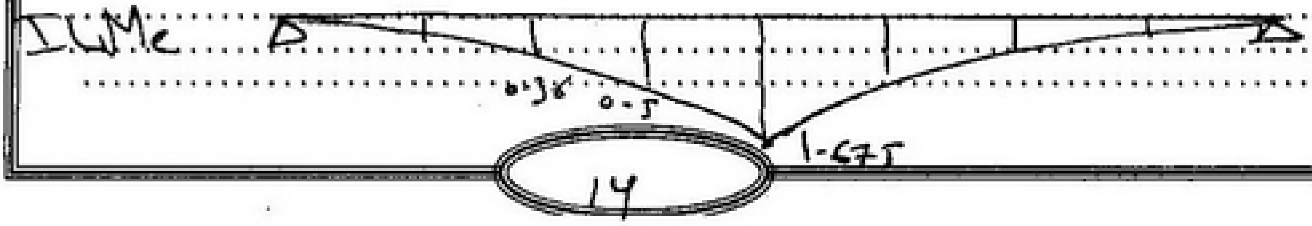
—

$IL\,N_{fe} = \text{zero}$

—

$IL\,M_e = IL\,M_{e_0} + (-3)\,IL\,N_{fh}$





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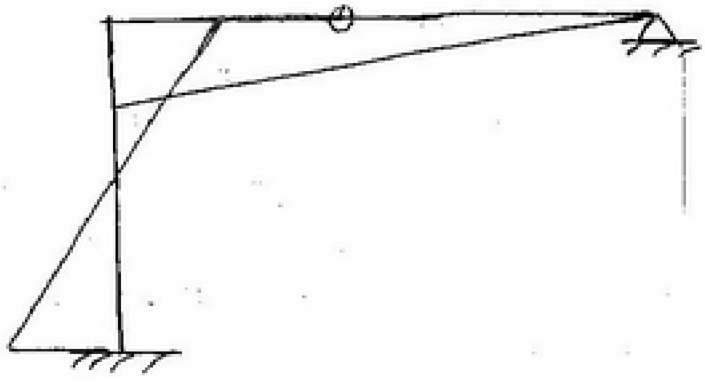
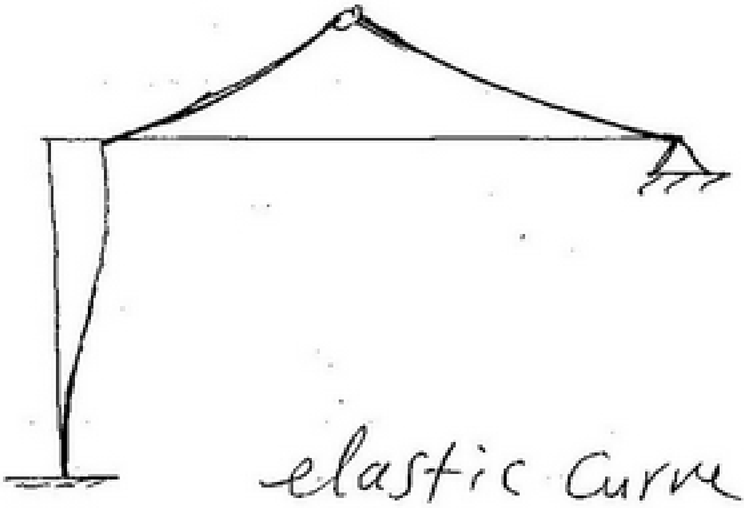
Q.6

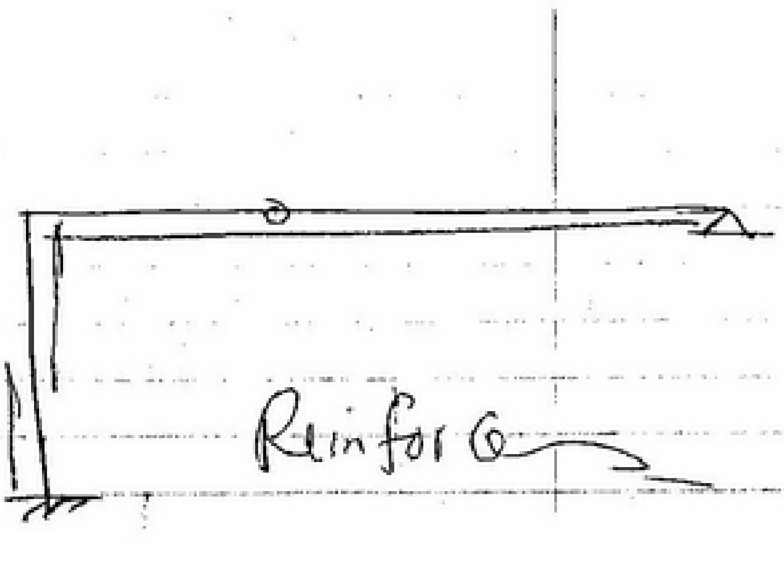
(a)



B.M.D



elastic curve



Reinforce

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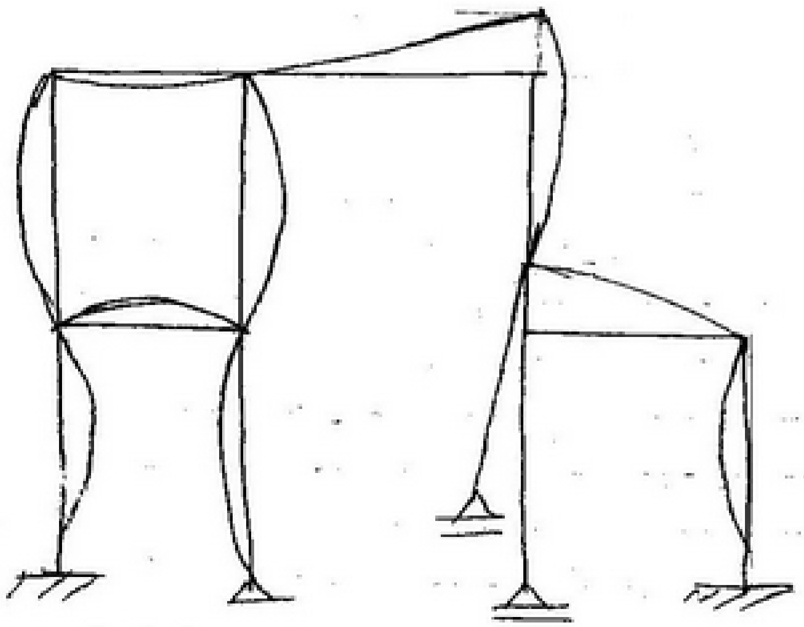
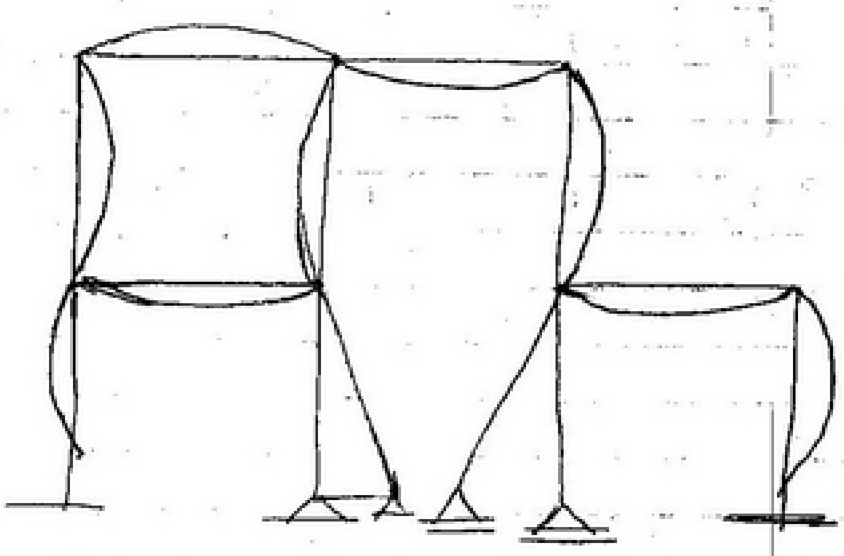
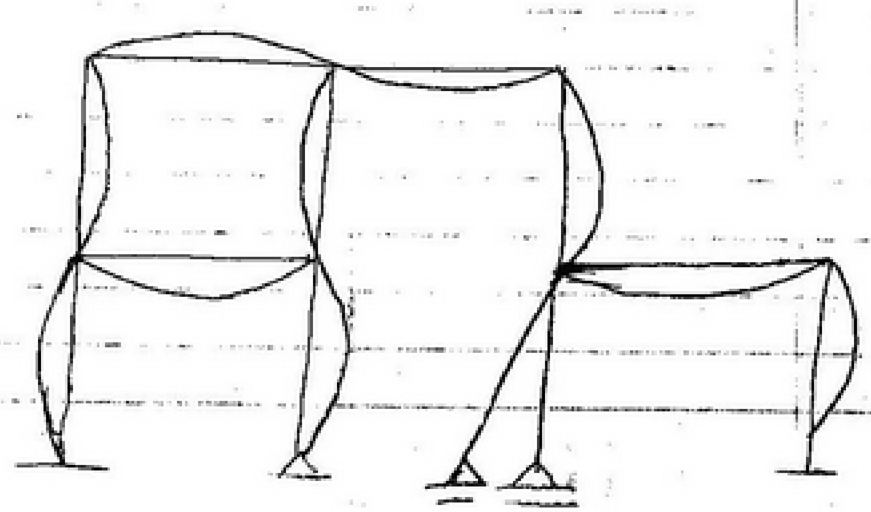


Y_C



X_B



M_A

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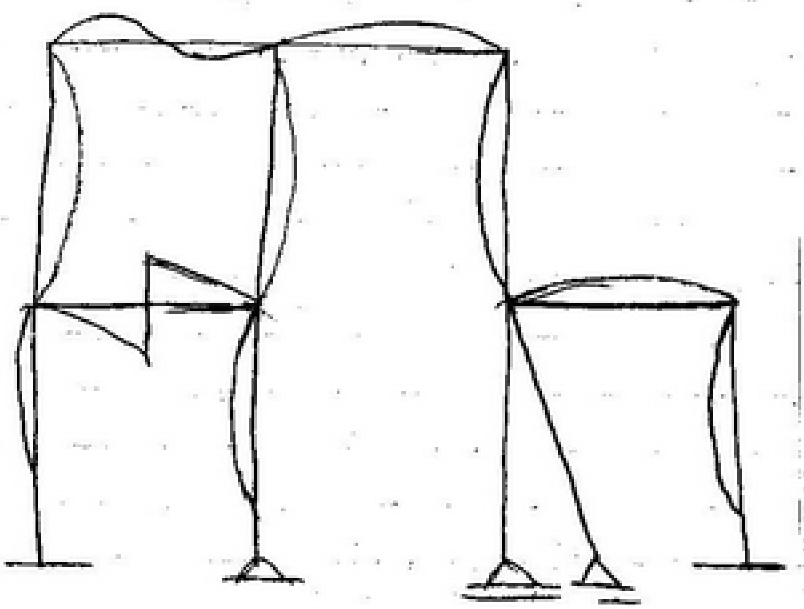
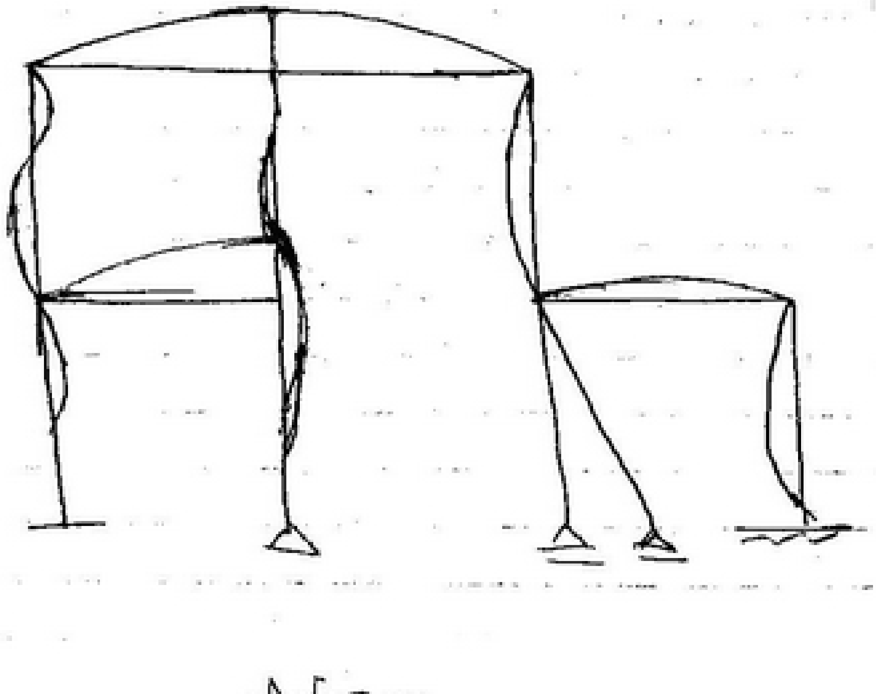


ILQf



NG

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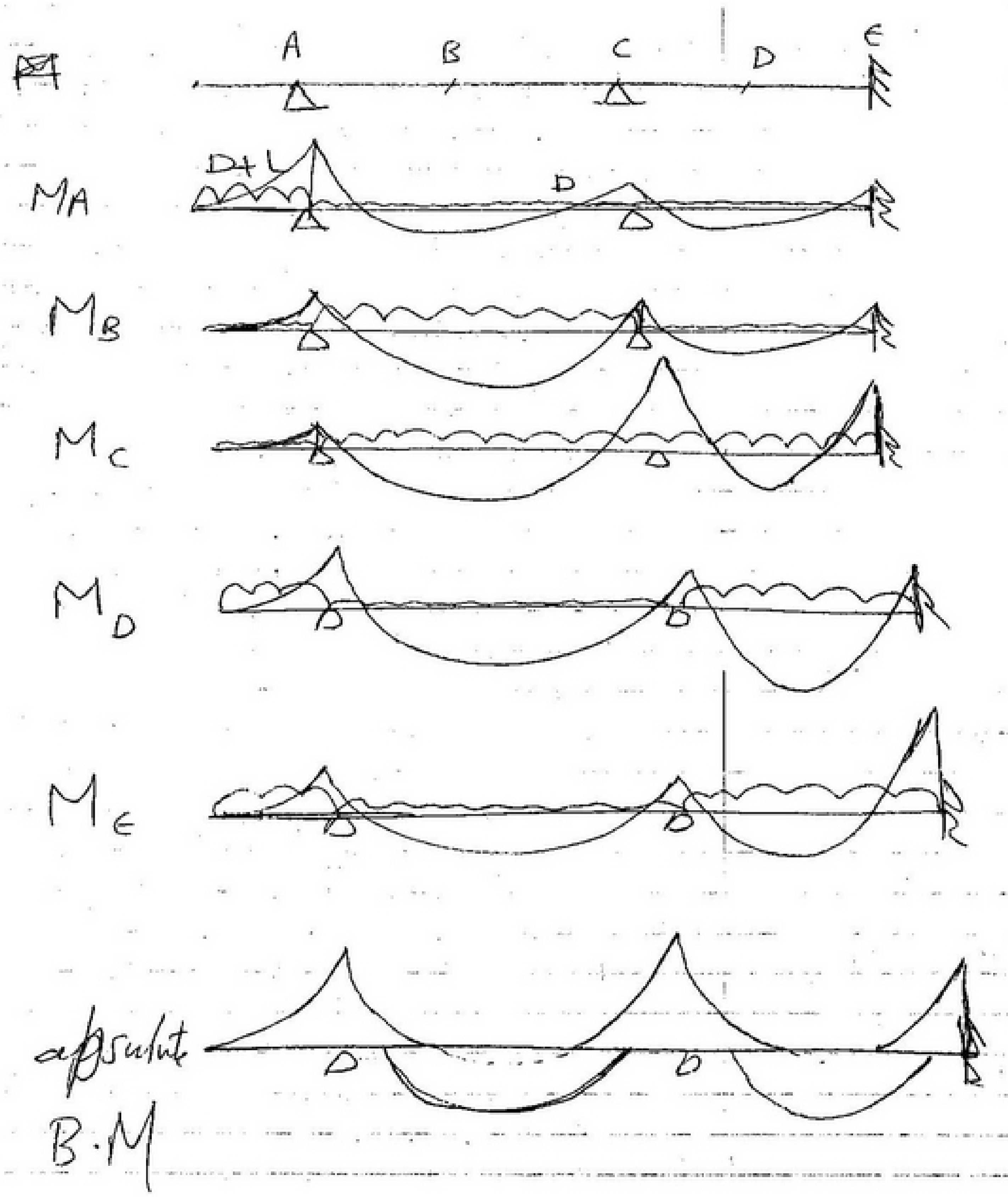

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Course Name : Structural Mechanics (2)
Course Code :
Level : Second Year Civil
Department : Structural Engineering
Term No. : 2

Zagazig University
Faculty of Engineering

Final Exam
Date : 28-5-2006
Time : 3 Hour
No. of pages : 2
No. of Questions : 6

SOLVE AS YOU CAN (Full mark from 60)

Problem No. (1) *(10 marks)*

For the shown fixed beam in Fig. (1), using ***the three moment equation***, draw the **B.M.D**, then

a) Calculate the maximum deflection in the beam and the rotation at point C

b) Compare the results with a simple beam

EI=3600 t.m^2

Fig. (1)

Problem No. (2) *(10 marks)*

For the shown columns in Fig. (2), calculate for each case

a) The critical and save load

b) Factor of safety against buckling

The cross-section is an angle 20x20x2 cm

Steel 37 L= 3.00 m

E= 2000 t/ cm^2 , A=76.4 cm^2

$I_x = I_y = 2850$ cm^4 & $I_{xy} = 1690$ cm^4

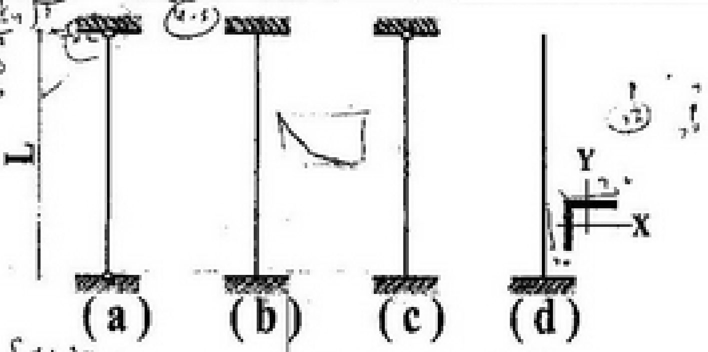

Fig. (2)

Problem No. (3) *(11 marks)*

For the column **AC** (Steel 37) shown in Fig. (3), determine the maximum permissible uniform load w

Section of column is BFIB NO. 40

E= 2000 t/ cm^2 , A=209 cm^2,

I_x = 60640 cm^4 & I_y = 11700 cm^4

$\sigma_{pt} = 1.2$ t/m^2 $\sigma_{pc} = 1.1$ t/m^2

$\sigma_{pb} = \dfrac{6000}{(\lambda)^2}$ $\lambda = \dfrac{l_b}{i} \geq 104$

$\sigma_{pb} = 1.1 - 0.00005(\lambda)^2$ $\lambda < 104$

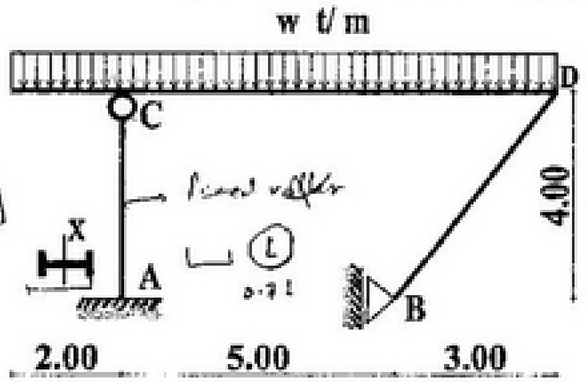

Fig. (3)

Problem No. (4) *(11 marks)*

For the beam shown in Fig. (4), calculate and draw the influence lines for Y_C, M_A, Q_E and M_B

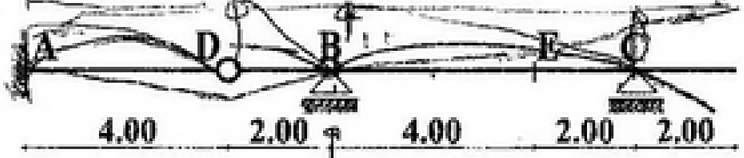

Fig. (4)

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Problem No. (5) *(12 marks)*

For the shown statically indeterminate trussed frame (Fig. 5), calculate and draw the influence lines for Y_A, M_G, N_{FE}, and M_E.

EI_{frame} = 20000 t.m² **EA_{Frame} = 80000 t** **EA_{links} = 40000 t**

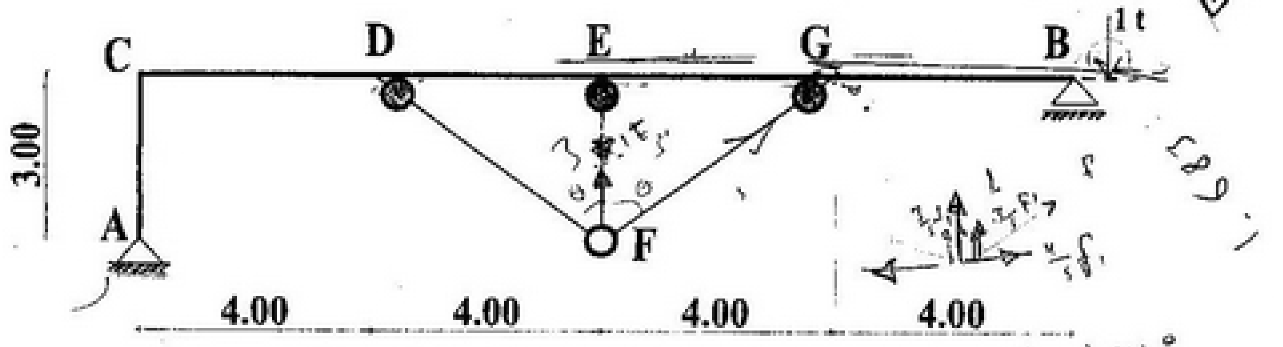

Fig. (5)

Problem No. (6) *(12 marks)*

a) For the structure shown in figure (6-a), without calculations, sketch the elastic curve, the bending moment diagram and the main steel reinforcement.

b) For the structure shown in figure (6-b), without calculations, sketch the influence lines for Y_B, X_C, M_A, N_F and Q_F

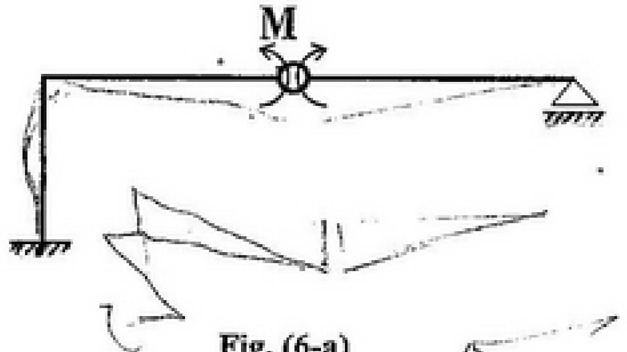

Fig. (6-a)

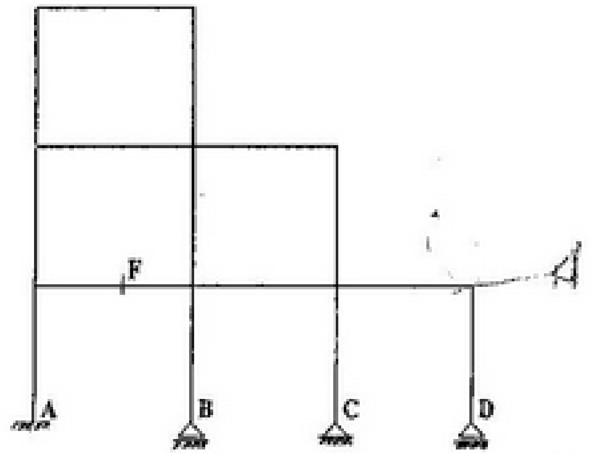

Fig. (6-b)

Prof. Dr. Sayed Abd-El Salam
Assist.Prof. Osman Shallan

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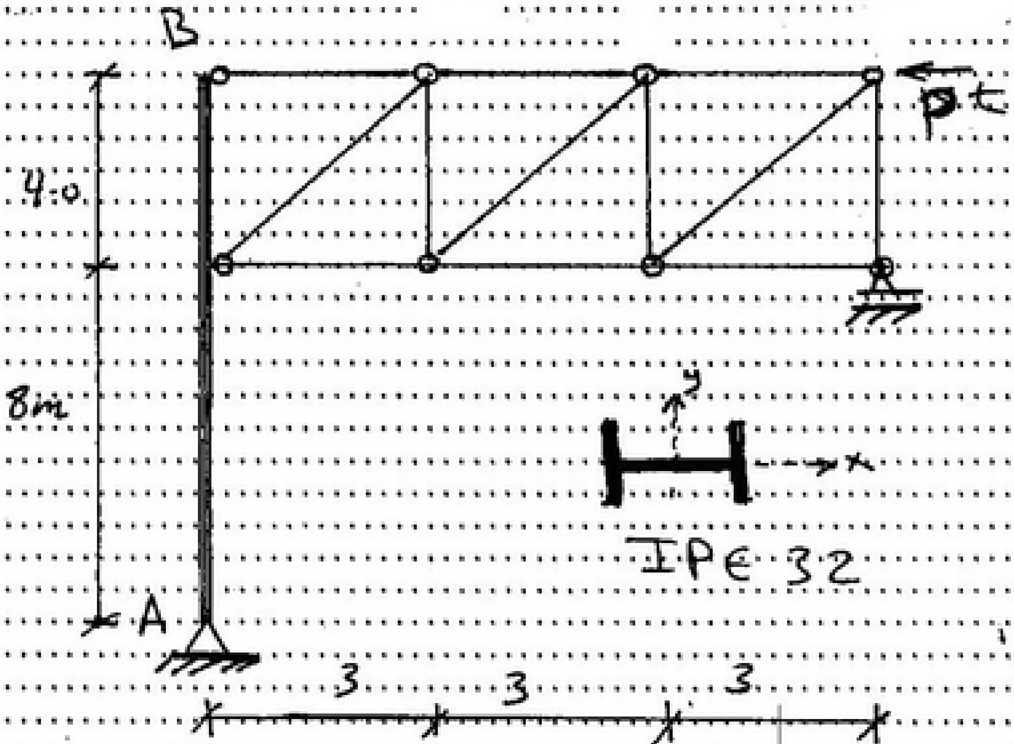

Solution

Find P_{max}

For IPE 32

$A = 50\ cm^2$

$I_x = 2000\ cm^4$

$I_y = 300.00\ cm^4$

$E = 2000\ t/cm^2$

St 44

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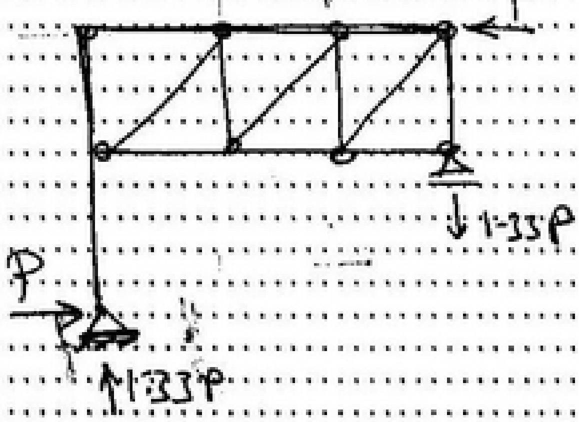

$N = 1.33P$

$M_y = 8P\ t.m = 800P$

* $l_b = 1200\ cm$

* $r_{min} = \sqrt{\frac{2000}{50}} = 20$

* $\lambda = \frac{1200}{20} = 60$

$\therefore F_{pb} = 1.3 - 0.000065\lambda^2$

$= 1.066\ t/cm^2$

$\therefore$

$$\frac{N}{A} * \frac{F_{pc}}{F_{pb}} + \frac{M_y}{I_y} \cdot x \leq F_{pc}$$

$$\frac{1.33P}{50} * \frac{1.3}{1.066} + \frac{800P}{30000} * 16 = 1.3$$

$P = 28\ ton$ o.K

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Revision

FINAL

STRUCTURE
PART (1)

الفرقة الثانية - مدني

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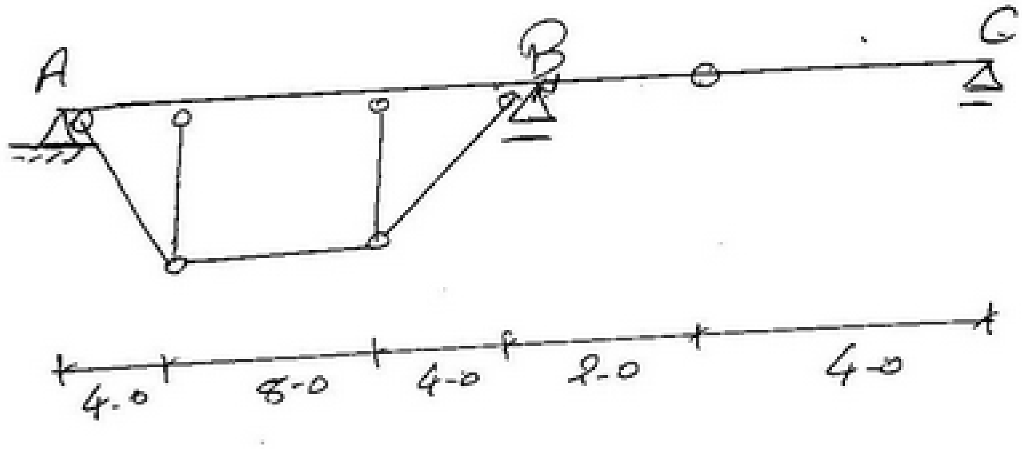
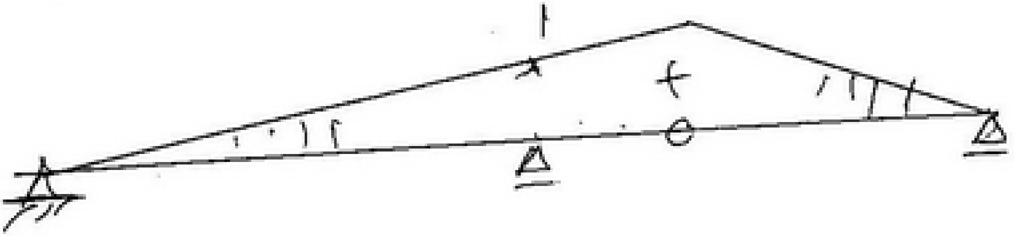
titanic_ship1912@yahoo.com

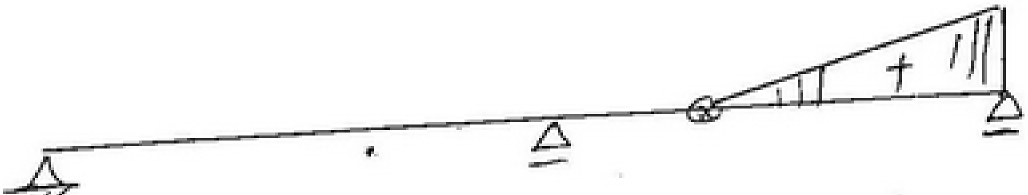
EX :



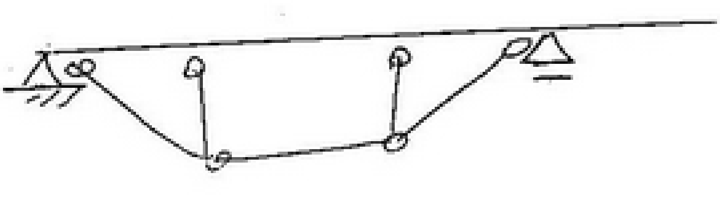
I.L-y_A



I.L-y_B



I.L-y_C



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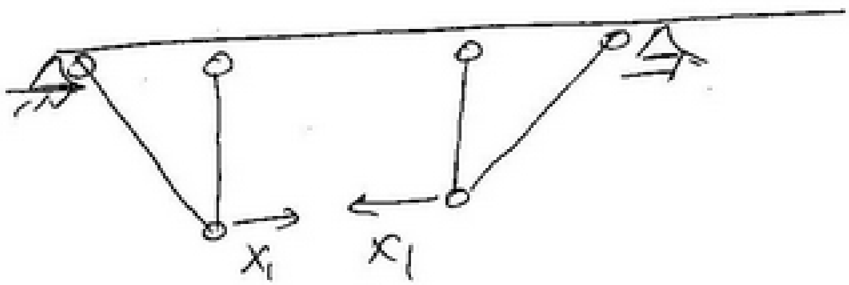
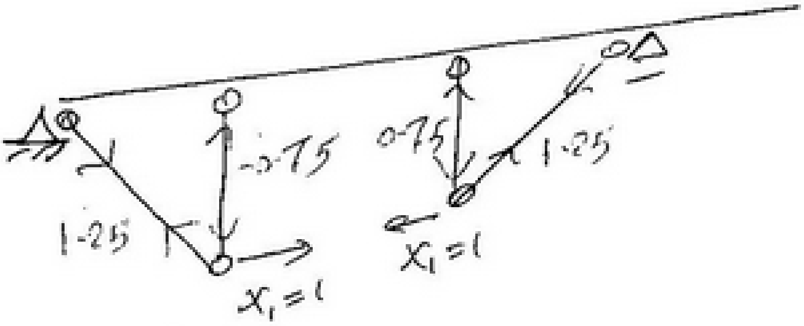
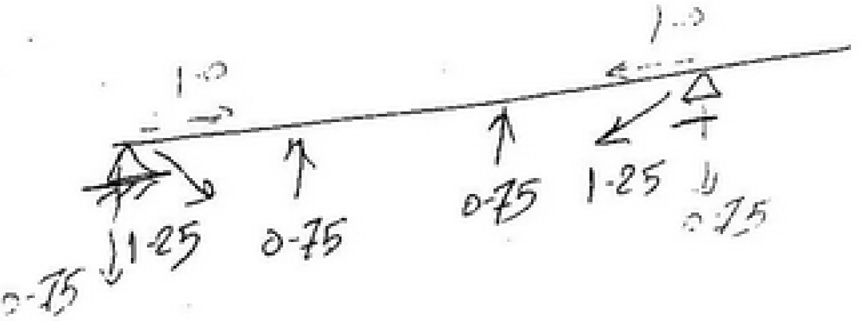


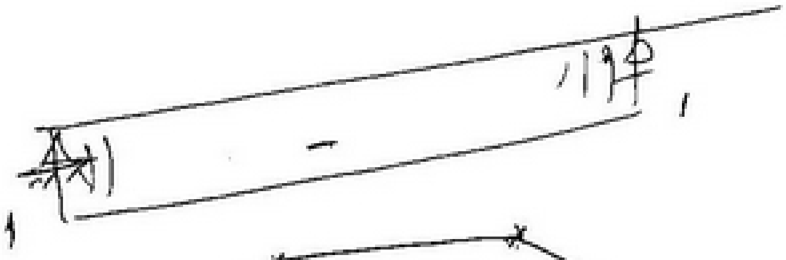
N_1 Link



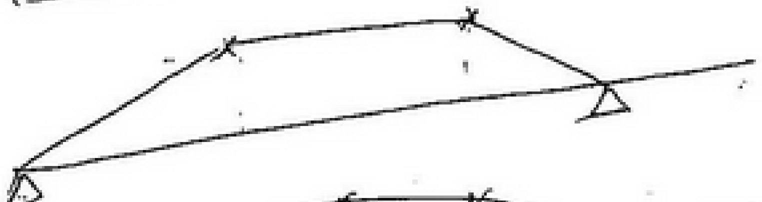


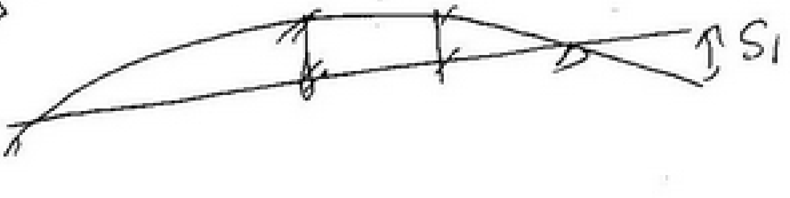
S_{11} ✓

X_1 ✓



B.M.D





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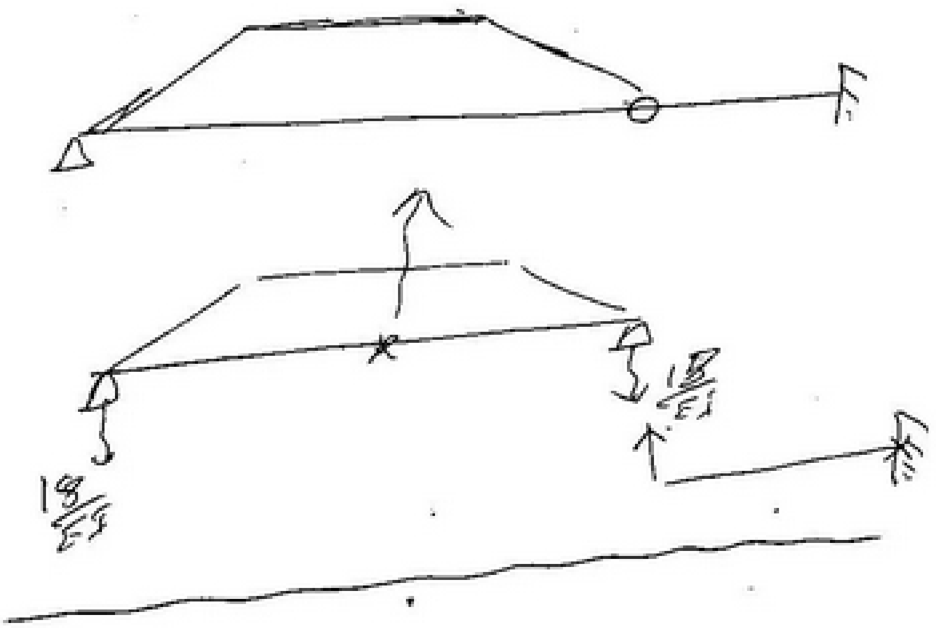
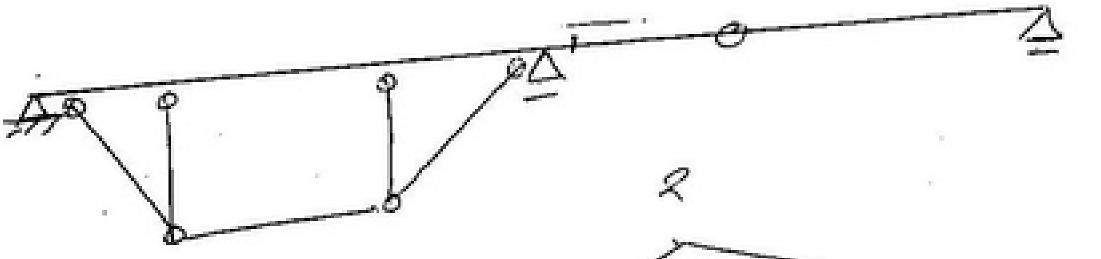
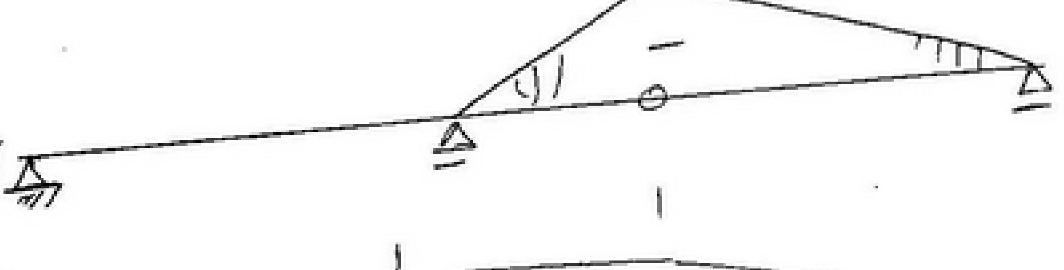
Conj. Beam







I.L. M_B

I.L. Q_{B_R}

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Ex: final 2001 :

I.L - y_B

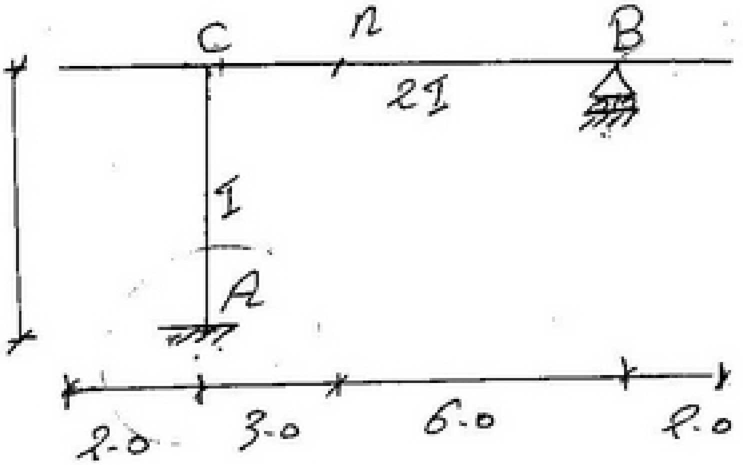
I.L - Q_n

I.L - Q_{CR}

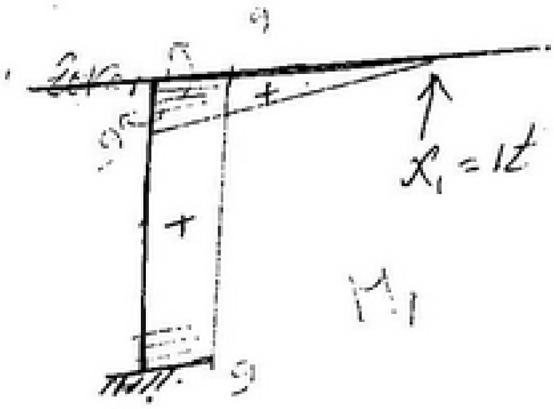
I.L - M_n

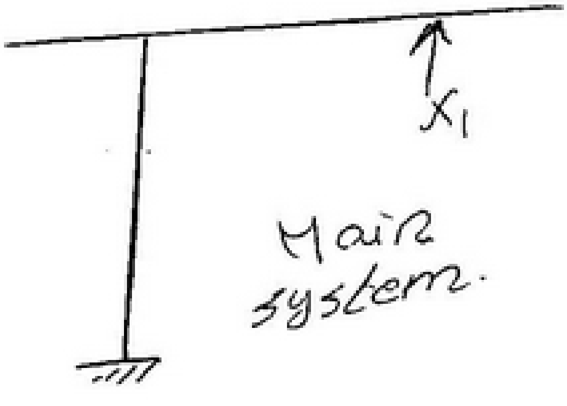
I.L - M_B

I.L - M_{CR}



*) solution :

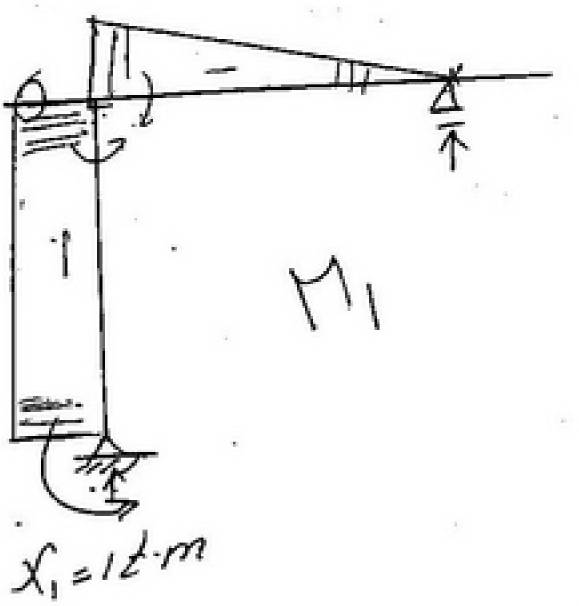


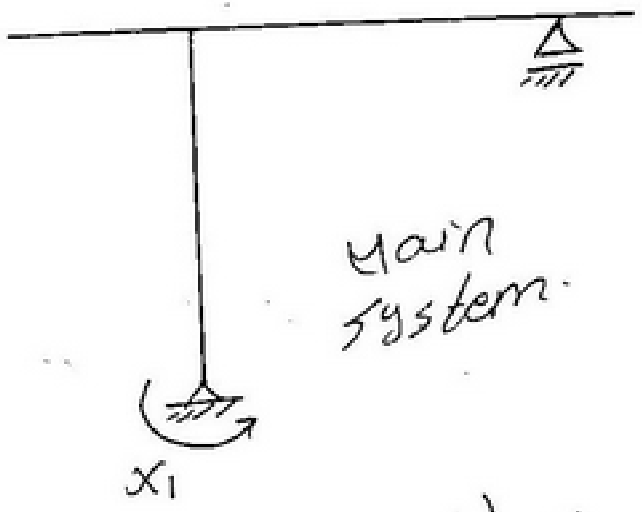


$$\delta_{11} = \int \frac{M_1^2}{EI} dL$$

$$= \frac{1}{EI}\left[\left(\frac{1}{2}\,\frac{9*9*9}{3}\right) + (9*4*9)\right] = \frac{445.5}{EI}$$

Frame (2I) لا نفصل نزل الـ fixed عشان

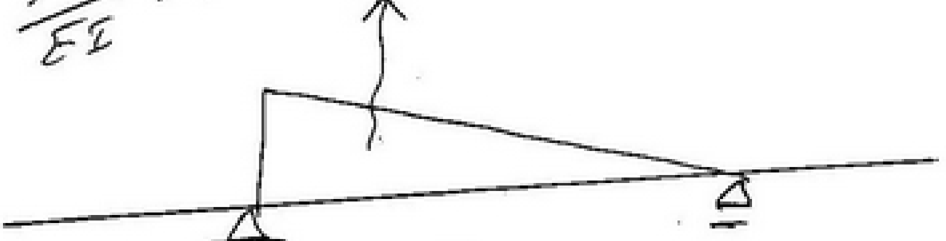


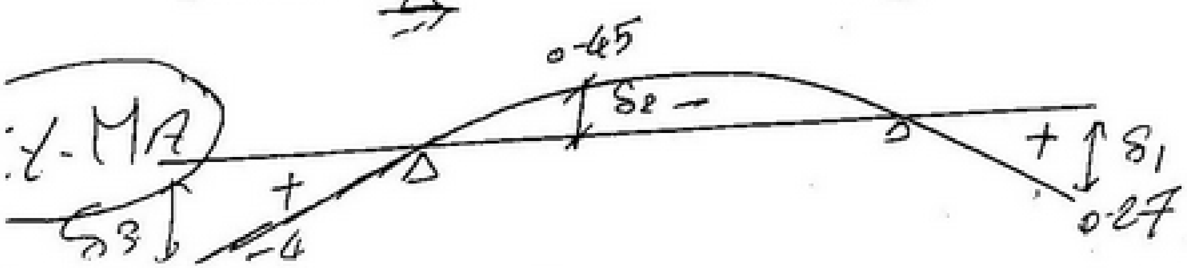


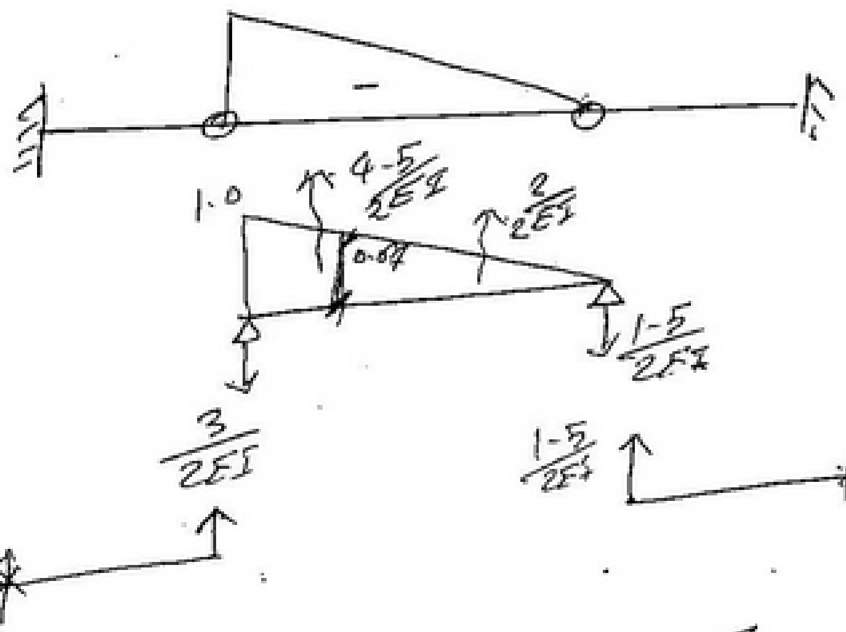
$$\delta_{11} = \int \frac{M_1^2}{EI} dL = \frac{1}{EI}\left[(1*4*1) + \left(\frac{1*1*9}{3}\right)*\frac{1}{2}\right] = \frac{5.5}{EI}$$

$$\delta_{11} X_1 = 1.0 \implies X_1 = \frac{EI}{5.5}$$

$$\frac{5.5}{EI} X_1 = 1.0$$







$$S_1 = \frac{1}{2EI}\left[(1.5 * 2)\right] * \frac{EI}{5.5} = 0.27$$

$$S_2 = \frac{1}{2EI}\left[\left(2 * \tfrac{1}{3} * 6\right) - (1.5 * 6)\right] * \frac{EI}{5.5}$$

$$= -0.45$$

$$S_3 = \frac{1}{2EI}\left[(3 * 2)\right] * \frac{EI}{5.5} = 0.54$$

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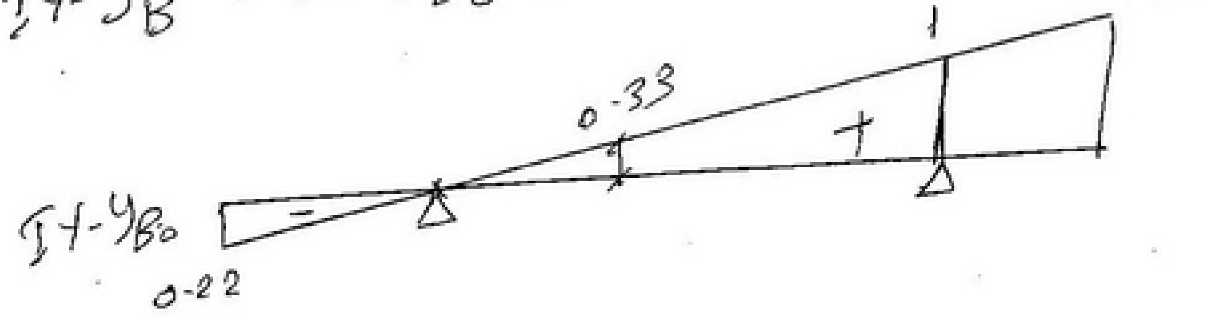
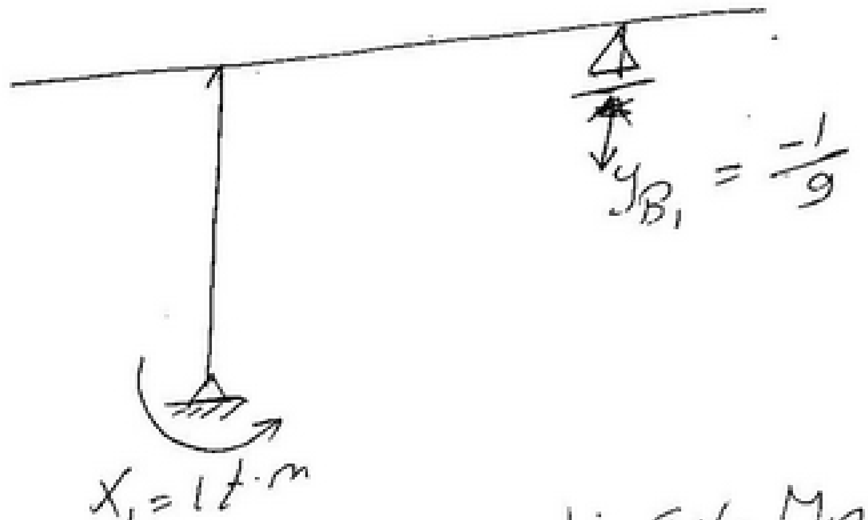
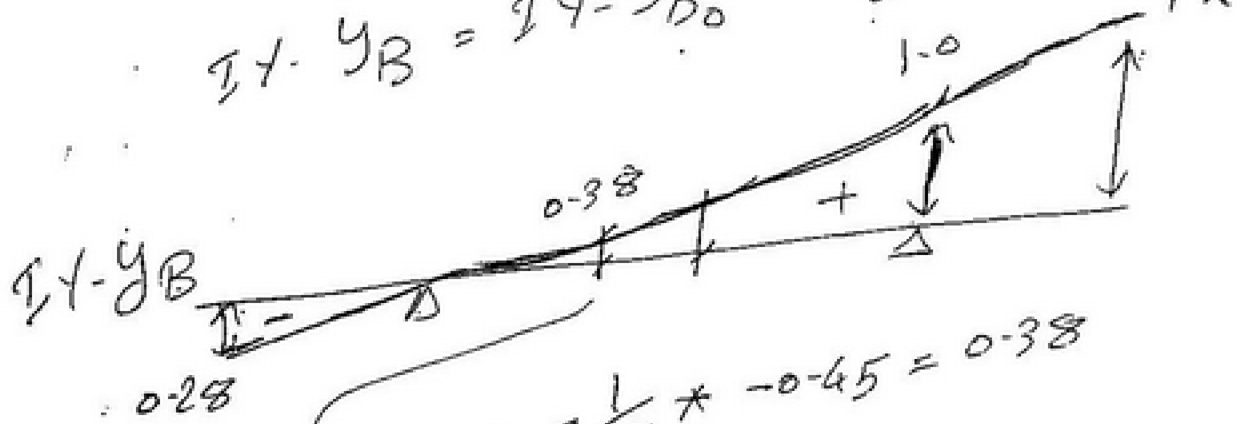
$$I.L\text{-}y_B = I.L\text{-}y_{B_0} + y_{B_1}\, I.L\text{-}M_A$$





$$I.L\text{-}y_B = I.L\text{-}y_{B_0} - \frac{1}{9}\, I.L\text{-}M_A$$



$$= 0.33 - \frac{1}{9} * -0.45 = 0.38$$

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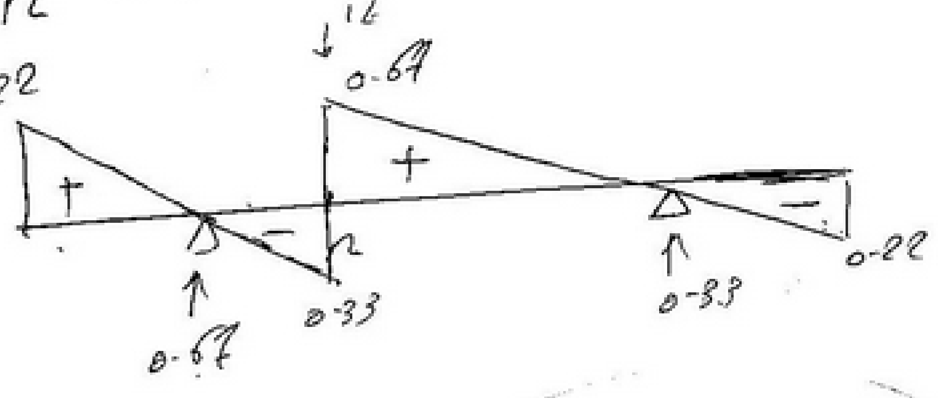
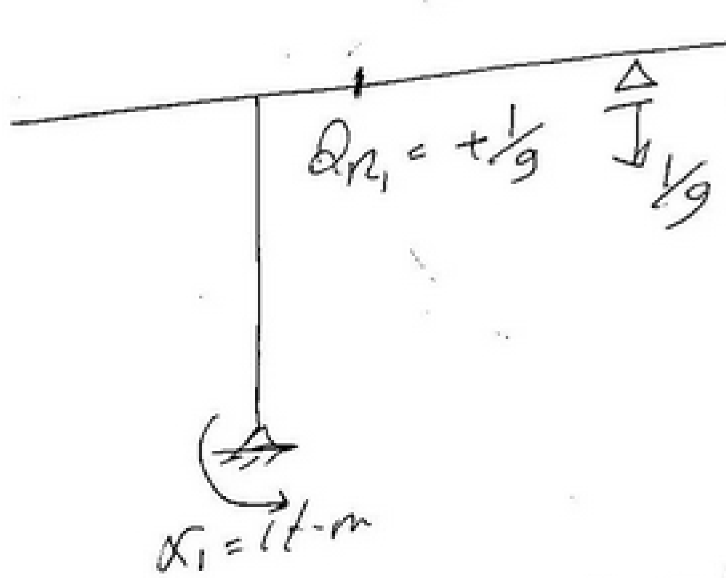
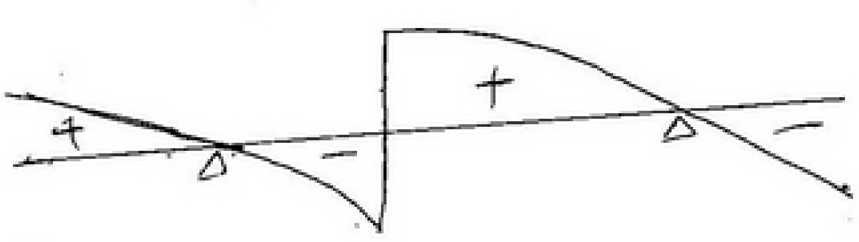
$$I.L\text{-}Q_n = I.L\text{-}Q_{n_0} + Q_{n_1}\, I.L\text{-}M_A$$



$I.L\text{-}Q_{n_0}$



$$I.L\text{-}Q_n = I.L\text{-}Q_{n_0} + \frac{1}{9}\, I.L\text{-}M_A$$



$I.L\text{-}Q_n$

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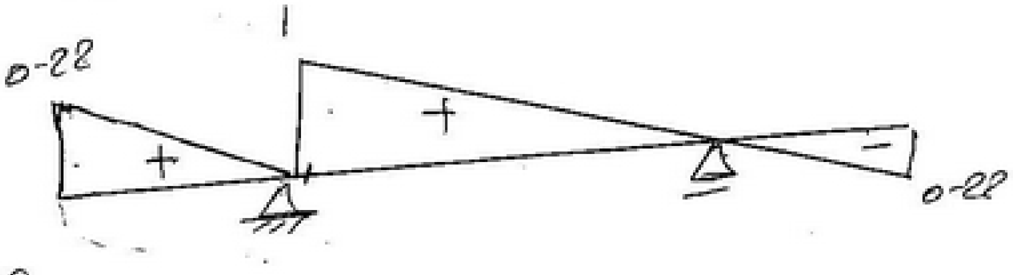
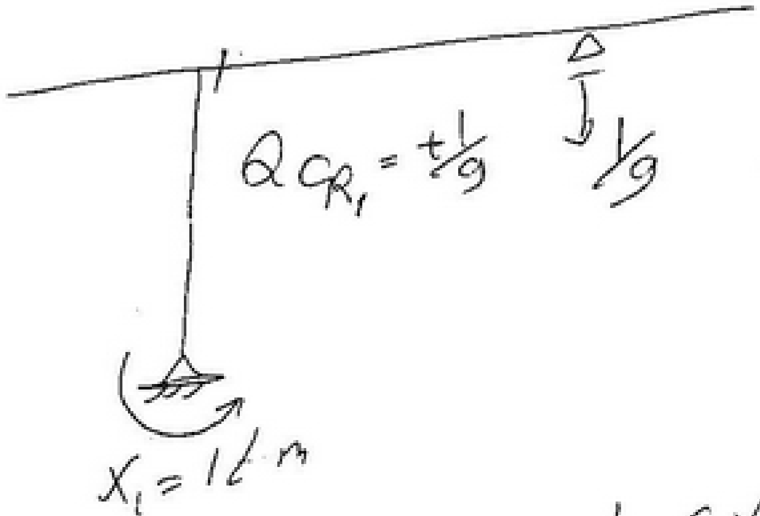
titanic_ship1912@yahoo.com

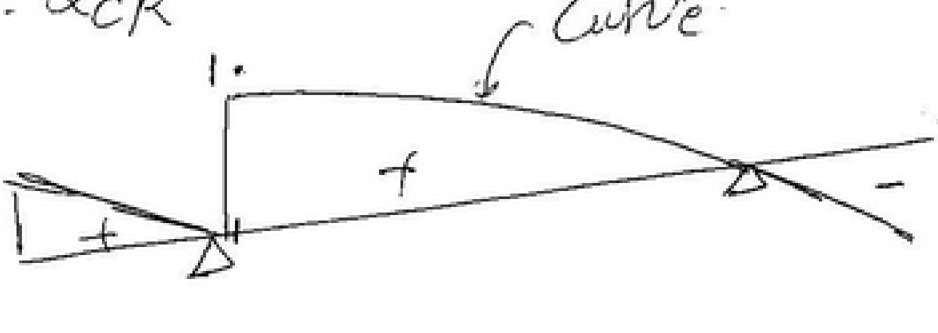
$I.L.\ Q_{CR} = I.L.\ Q_{CR_0} + Q_{CR_1}\ I.L.\ M_A$



$I.L.\ Q_{CR_0}$



$I.L.\ Q_{CR} = I.L.\ Q_{CR_0} + \frac{1}{9}\ I.L.\ M_A$



$I.L.\ Q_{CR}$

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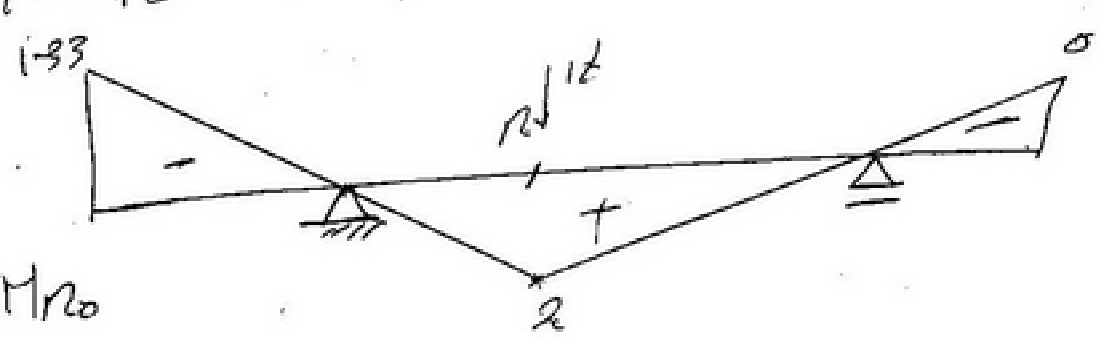
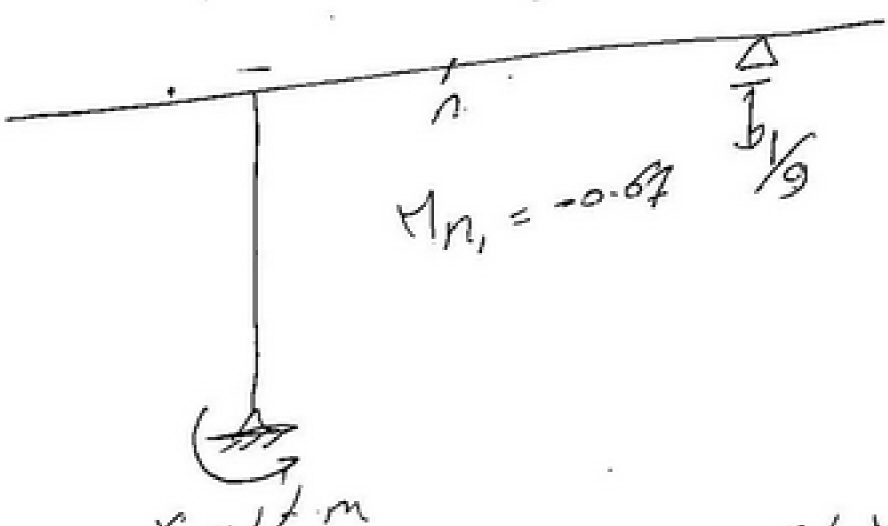
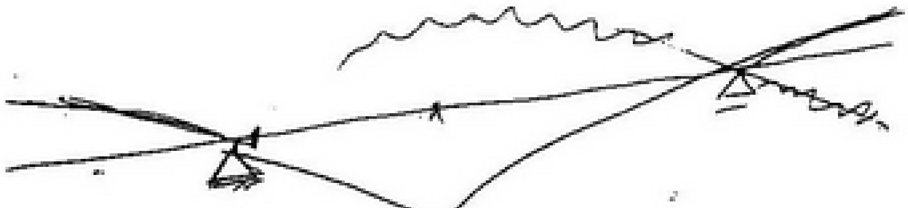
$I.L\text{-}M_r = I.L\text{-}M_{r_0} + M_{r_1}\, I.L\text{-}M_R$



$I.L\text{-}M_{r_0}$



$I.L\text{-}M_r = I.L\text{-}M_{r_0} - 0.67\, I.L\text{-}M_R$



$I.L\text{-}M_r$

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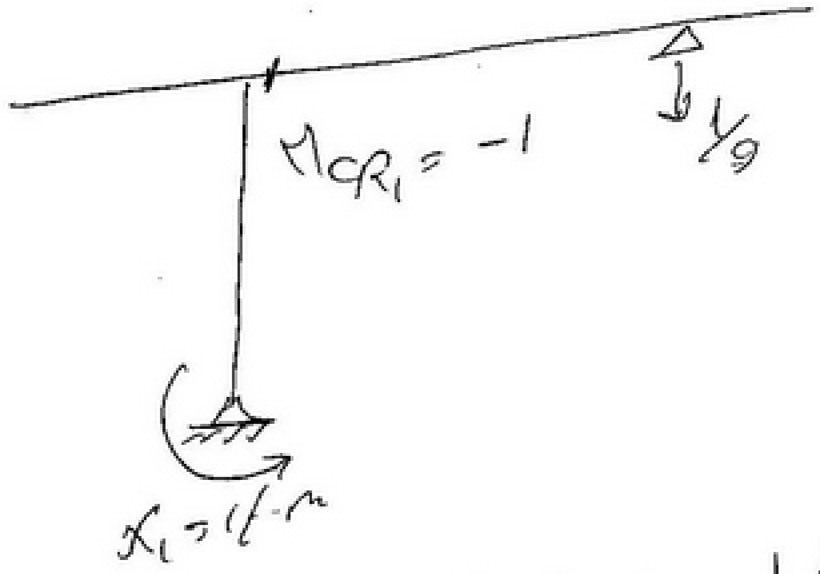
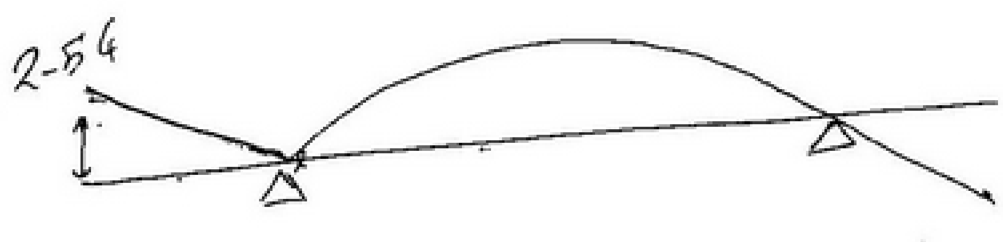
$$I.L\text{-}M_{CR} = I.L\text{-}M_{CR_0} + M_{CR_1}\ I.L.\ M_A$$

$I.L\text{-}M_{CR}$



$$I.L\text{-}M_{CR} = I.L\text{-}M_{CR_0} - 1 * I.L\text{-}M_A$$



$I.L\text{-}M_{CR}$

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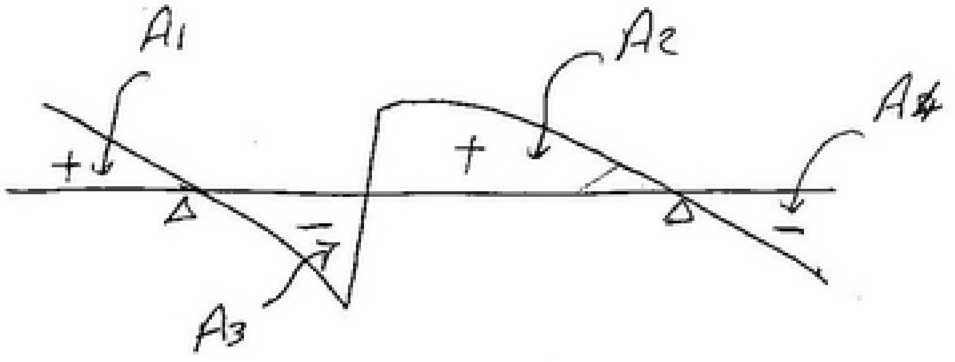
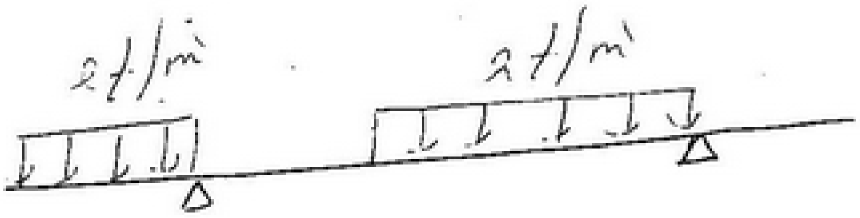
Max. value of Q_n

Moving load $= 2t/m'$

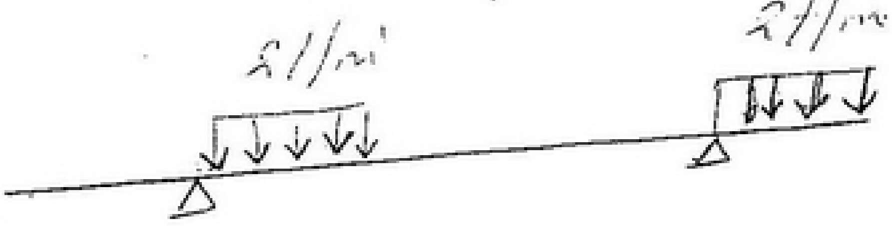
I.L-Q_n





Max. +ve effect

$$Q_{n\,max(+ve)} = (A_1 + A_2) *$$ قيمة الحمل ←



Max. −ve effect

$$Q_{n\,max.(-ve)} = -(A_3 + A_4) * 2$$

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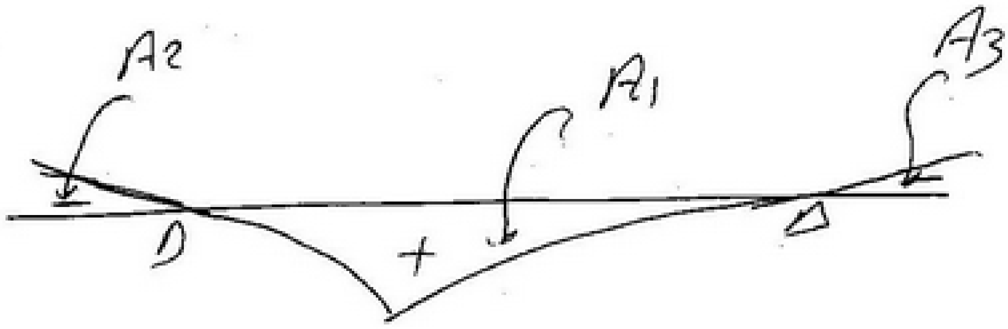
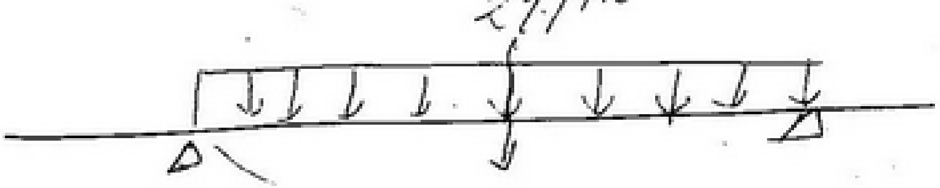
* I.L - M_n Max value

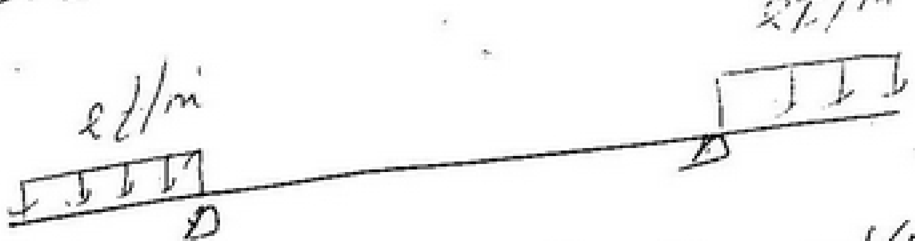


I.L - M_n



Max +ve effect

$$M_{n\,(+ve)} = A_1 * 2 = +ve$$



$$M_{n\,(-ve)} = -(A_2 + A_3) * 2 = -ve$$

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titanic_ship1912@yahoo.com

Revision

FINAL

STRUCTURE PART (2)

الفرقة الثانية - مدني

15

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Course Name : Structural Mechanics (2)		**Final Exam**	
Course Code :		**Date**	: 20-5-2007
Level : Second Year Civil	Zagazig University	**Time**	: 3 Hour
Department : Structural Engineering	Faculty of Engineering	**No. of pages**	: 2
Term No. : 2		**No. of Questions**	: 6

SOLVE AS YOU CAN (Full mark from 60)

Problem No. (1) *(10 marks)*

For the columns shown in figure (1), derive the formula of buckling length for each case.

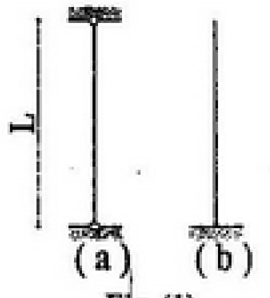

Fig. (1)

Problem No. (2) *(10 marks)*

For the shown strut, if the beam is restricted in plane and out of plane as shown in figure (2), Find the max. value of Δt which make the strut still stable.

Fig. (2)

Cross Section is (SIB NO. 32)

Steel 52 $\alpha = 1.2\times10^{-5}$

$E = 2000\ t/cm^2$, $A = 77.7\ cm^2$,

$I_x = 12150\ cm^4$ & $I_y = 555\ cm^4$

Problem No. (3) *(11 marks)*

Figure (3) shows a column (Steel 37) with height of 5.0 m. and has two hinged at the ends. It carries lateral and vertical loads as shown. If the cross-section of the column is circular with diameter 20 cm, find the maximum horizontal permissible load **F** and the corresponding maximum deflection at the med-height of the column. Consider the moment due to vertical force.

$E = 2000\ t/cm^2$, $\sigma_{pc} = 1.1\ t/m^2$

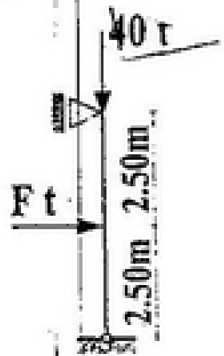

Fig. (3)

Problem No. (4) *(11 marks)*

For the beam shown in Fig. (4), calculate and draw the influence lines for Y_C, M_A, Q_E, Q_F, Q_G and M_B. Also, find the maximum values for Y_C and M_B due to 2t/m dead load and 3 t/m live load

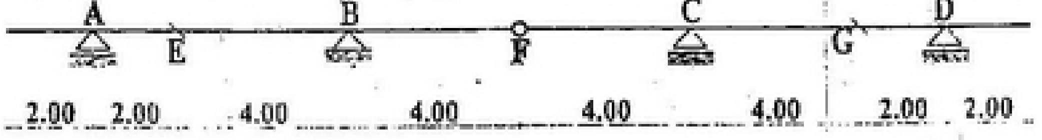

Fig. (4)

اقلب الصفحة من فضلك

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Problem No. (5) *(12 marks)*

For the shown statically indeterminate trussed beam (Fig. 5), introduce the influence lines for Y_B, M_G, N_{FH}, N_{FE} and M_G.

$EI_{frame} = 20000\ t.m^2$ $EA_{frame} = 80000\ t$ $EA_{links} = 40000\ t$

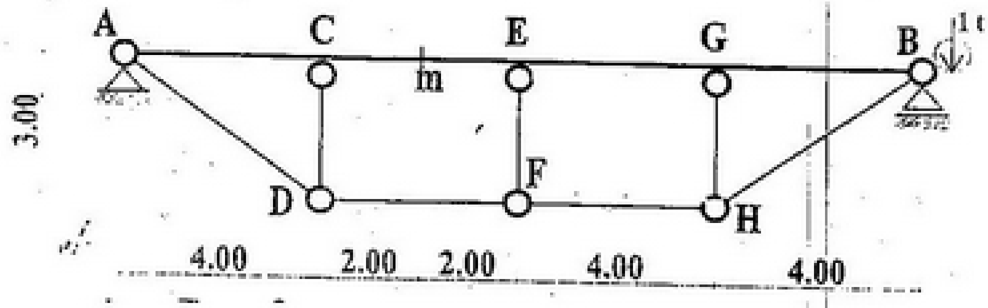

Fig. (5)

Problem No. (6) *(12 marks)*

a) For the structure shown in figure (6-a), without calculations, sketch the elastic curve, the bending moment diagram and the main steel reinforcement.

b) For the structure shown in figure (6-b), without calculations, sketch the influence lines for Y_C, X_B, M_A, Q_F and N_G

c) For the beam shown in figure (6-c) sketch the absolute bending moment

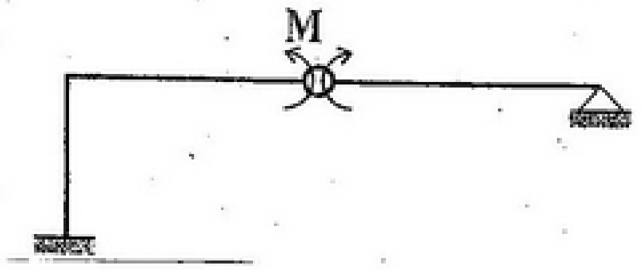

Fig. (6-a)

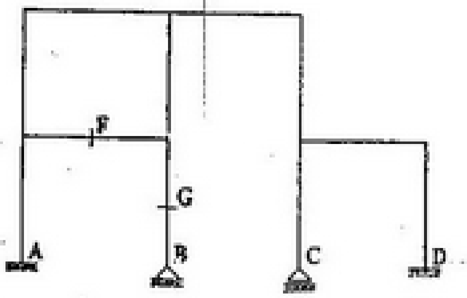

Fig. (6-b)

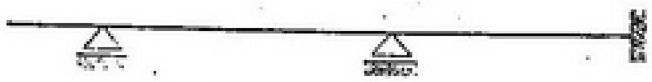

Fig. (6-c)

Prof. Dr. Sayed Abd-El Salam
Assist.Prof. Osman Shallan
Dr. Hanaa Elsayed

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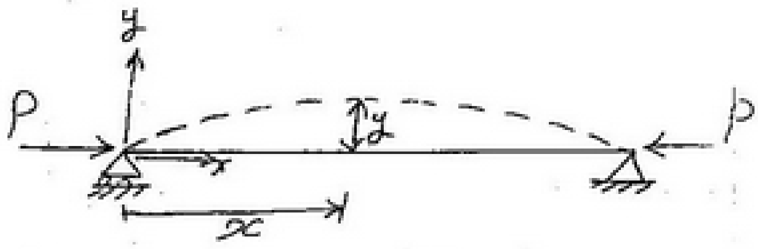
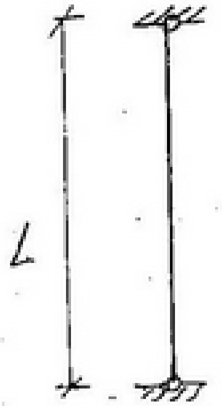
titanic_ship1912@yahoo.com

Problem No. 1 :

*) Case of hinged - hinged column :





$$\frac{d^2y}{dx^2} = \frac{M}{EI} \Rightarrow M = -Py$$

$$\therefore y'' = \frac{-P}{EI}y \Rightarrow y'' + C^2 y = 0$$

where : $C^2 = \frac{P}{EI}$

$$\therefore \; y = C_1 \cos Cx + C_2 \sin Cx$$

Boundary condition :

1) at $x = 0 \quad y = 0$

$$0 = C_1 + 0 \Rightarrow C_1 = 0$$

$$\therefore y = C_2 \sin Cx$$

$$y' = CC_2 \cos Cx$$

2) at $x = \frac{L}{2} \quad y' = 0$

$$0 = CC_2 \cos\left(\frac{CL}{2}\right)$$

$C_2 \neq 0$ "Case of no buckling"

$$\therefore \cos\frac{CL}{2} = 0 \Rightarrow \frac{CL}{2} = \frac{\pi}{2}$$

$$CL = \pi \Rightarrow \sqrt{\frac{P}{EI}}\, L = \pi$$

$$\therefore \underline{P}\, L^2 = \pi^2 \qquad \therefore P_{cr.} = \frac{\pi^2 EI}{L^2}$$

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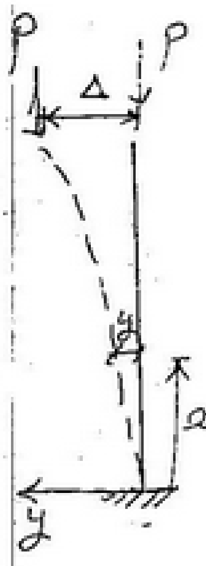
*) Case of Fixed - Free Column:



$$\frac{d^2y}{dx^2} = \frac{-M}{EI}$$

$$M = -P(\Delta - y)$$

$$\frac{d^2y}{dx^2} = \frac{P}{EI}(\Delta - y)$$

$$y'' + \frac{P}{EI}y = \frac{P}{EI}\Delta$$

$$y'' + C^2 y = C^2\Delta$$

$$\therefore y = C_1 \cos cx + C_2 \sin cx + \Delta$$

Boundary Condition:

1) at $x = 0$ $\quad y = 0$

$$0 = C_1 + \Delta \qquad \therefore C_1 = -\Delta$$

$$\therefore y = -\Delta \cos cx + C_2 \sin cx + \Delta$$

$$y' = +c\Delta \sin cx + cC_2 \cos cx$$

2) at $x = 0$ $\quad y' = 0$

$$0 = 0 + cC_2 \quad \Rightarrow C_2 = 0$$

$$\therefore y = \Delta(1 - \cos cx)$$

3) at $x = l$ $\quad y = \Delta$:

$$\Delta = \Delta(1 - \cos cl)$$

$$\cos cl = 0$$

$$cl = \frac{\pi}{2} \Rightarrow \sqrt{\frac{P}{EI}}\, l = \frac{\pi}{2}$$

$$\therefore \frac{P}{EI} l^2 = \frac{\pi^2}{4} \Rightarrow P_{cr} = \frac{\pi^2 EI}{4l^2} \Rightarrow l_b = 2l$$

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*). Problem No. (2) :-

- stresses due to Temperature in Part AC = zero due to Free moving.
- stress due to Temperature developed in Part (CD)

$$\sigma_{Temp.} = \alpha \Delta t E$$
$$= 1.2 * 10^{-5} * \Delta t * 2000$$
$$= 0.024 \Delta t$$

$$\sigma_{cr.} = \frac{\pi^2 E}{\lambda^2}$$

$L_b = 0.7 * 9 = 630 \text{ cm}$ " Case of hinged - fixed "

$$i_{min} = \sqrt{\frac{I_{min}}{A}} = \sqrt{\frac{555}{77.7}} = 2.67 \text{ cm}$$

$$\lambda = \frac{L_b}{i_{min}} = \frac{630}{2.67} = 235.72$$

$$\therefore \sigma_{cr.} = \frac{\pi^2 * 2000}{(235.72)^2} = 0.355 \text{ t/cm}^2$$

$$\therefore \sigma_{Temp.} \ngtr \sigma_{cr.}$$

$$\therefore 0.024 \Delta t = 0.355$$

$$\boxed{\Delta t = 14.8^{\circ}\text{C}}$$

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Problem No. (3) :-

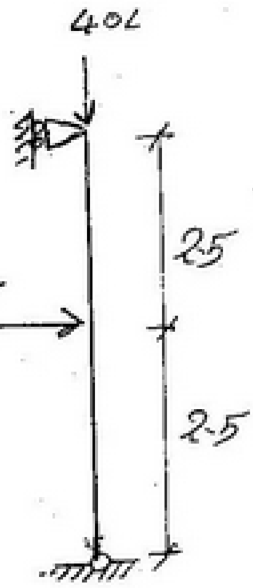
*) $D = 20cm$

$$A = \frac{\pi}{4} * 20^2 = 314.16 \, cm^2$$

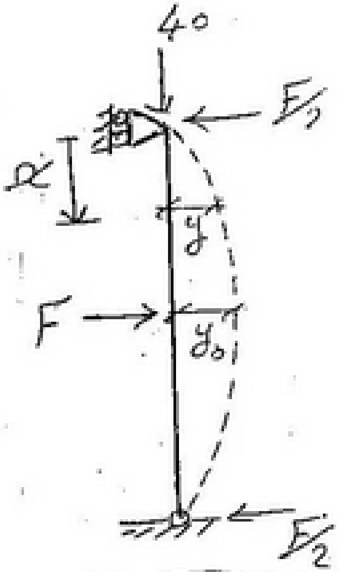
$$I_x = \frac{\pi}{64} D^4 = \frac{\pi}{64} * 20^4 = 7853.98 \, cm^4$$

$$I_y = 7853.98 \, cm^4$$

$$i_{min} = \sqrt{\frac{I_{min}}{A}} = \sqrt{\frac{7853.98}{314.16}} = 5 \, cm$$



- Consider the moment due to vertical load :- Assume $(P = 40)$



$$M = \frac{F}{2} x + P y$$

$$\frac{d^2y}{dx^2} = \frac{-M}{EI}$$

$$= \frac{1}{EI}\left[-\frac{Fx}{2} - Py\right]$$

$$y'' + \frac{P}{EI} y = \frac{-Fx}{2EI}$$

$$\therefore y = C_1 \cos cx + C_2 \sin cx - \frac{F}{2EIc^2} x$$

Boundary Condition :-

1) at $x = 0$ $y = 0$

$$0 = C_1 + 0 - 0 \Rightarrow C_1 = 0$$

$$y' = c C_2 \cos cx - \frac{F}{2EIc^2}$$

2) at $x = \frac{L}{2}$ $y' = 0$

$$0 = c C_2 \cos \frac{cL}{2} - \frac{F}{2EIc^2}$$

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$$C_2 = \frac{F}{2EIC^3 \cos\frac{cL}{2}}$$

$$\therefore y = \frac{F}{2EIC^3 \cos\frac{cL}{2}} \sin cx - \frac{F}{2EIC^2} x$$

$$= \frac{F}{2EIC^3 \cos\frac{cL}{2}} \sin cx - \frac{Fx}{2P}$$

3) at $x = \frac{L}{2}$, $y = y_0$

$$y_0 = \frac{F}{2EIC^3 \cos\frac{cL}{2}} \sin c\frac{L}{2} - \frac{FL}{4P}$$

$$= \frac{F}{2PC} \tan\frac{cL}{2} - \frac{FL}{4P}$$

Max. B.M.:

$$= \frac{FL}{4} + Py_0$$

$$= \frac{FL}{4} + \frac{F}{2C} \tan\frac{cL}{2} - \frac{FL}{4}$$

$$= \frac{F}{2C} \tan\frac{cL}{2}$$

$$\therefore C = \sqrt{\frac{P}{EI}} = \sqrt{\frac{40}{2000 \times 7853.98}} = 1.59 \times 10^{-3} \ 1/cm$$

$L = 5.0\,m = 500\,cm$

$$M_{max} = \frac{F}{2 \times 1.59 \times 10^{-3}} \tan\left(\frac{1.59 \times 10^{-3} \times 500}{2}\right) \rightarrow rad.$$

$$= 132F \ t.cm$$

$$= 1.32F \ t.m$$

$$\sigma_{max} = \frac{P}{A} + \frac{M}{Z} \ngtr \sigma_{PC}$$

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$$1.1 = \frac{40}{314.16} + \frac{132F}{7853.98/10}$$

$$\therefore F = 5.8\,t$$

$$y_0 = \frac{5.8}{2*40*1.59*10^{-3}} \tan\left(\frac{1.59*10^{-3}*500}{2}\right) - \frac{5.8*500}{4*40}$$

$$= ??$$

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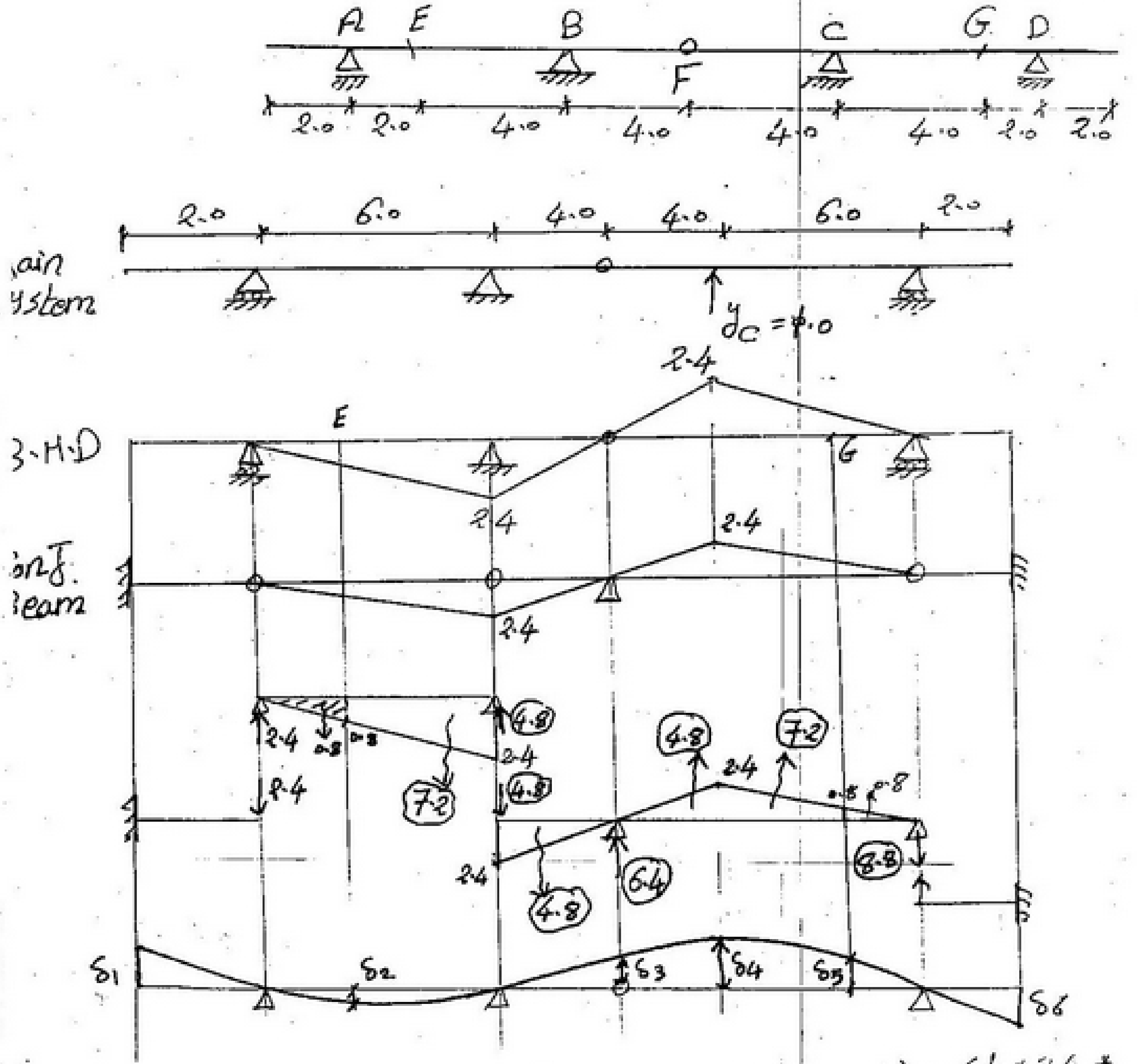
Problem (4) :



$$\delta_{11} = \int \frac{M_1^2}{EI} dL = \frac{1}{EI}\Big[\left(\tfrac{1}{2} * 2.4 * 6 * \tfrac{2}{3} * 2.4\right) + \left(\tfrac{1}{2} * 2.4 * 4 * \tfrac{2}{3} * 2.4\right) * 2 + \left(\tfrac{1}{2} * 2.4 * 6 * \tfrac{2}{3} * 2.\right.$$

$$= \frac{38.4}{EI}$$

$$X_1 \delta_{11} = 1.0 \implies X_1 * \frac{38.4}{EI} = 1.0$$

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$$\delta_1 = \frac{1}{EI} * \frac{EI}{38.4}\left[(-2.4*2)\right] = -0.125$$

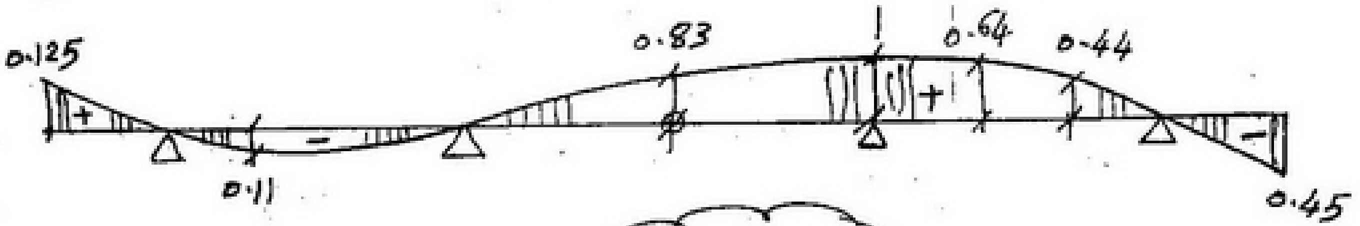
$$\delta_2 = \frac{1}{EI} * \frac{EI}{38.4}\left[(2.4*2) - (0.8*\frac{2}{3})\right] = 0.11$$

$$\delta_3 = \frac{1}{EI} * \frac{EI}{38.4}\left[(-4.8*4) + (-4.8*\frac{2}{3}*4)\right] = 0.83$$

$$\delta_4 = \frac{1}{EI} * \frac{EI}{38.4}\left[(7.2*2) - (8.8*6)\right] = -1$$

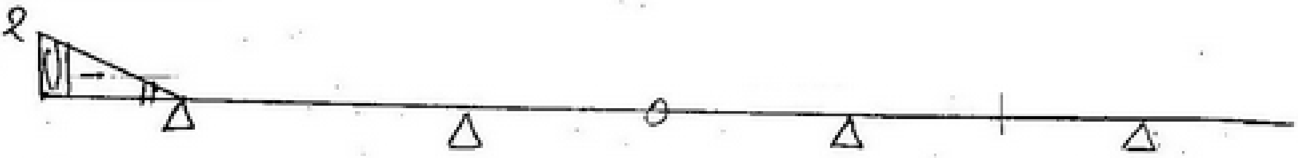
$$\delta_5 = \frac{1}{EI} * \frac{EI}{38.4}\left[(0.8*\frac{2}{3}) - (8.8*2)\right] = -0.44$$

$$\delta_6 = \frac{1}{EI} * \frac{EI}{38.4}\left[(8.8*2)\right] = 0.45$$



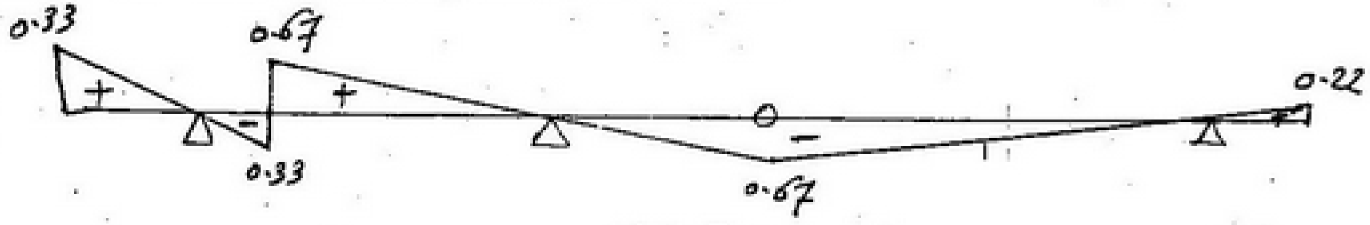
I.L. y_C

*) I.L. M_A :

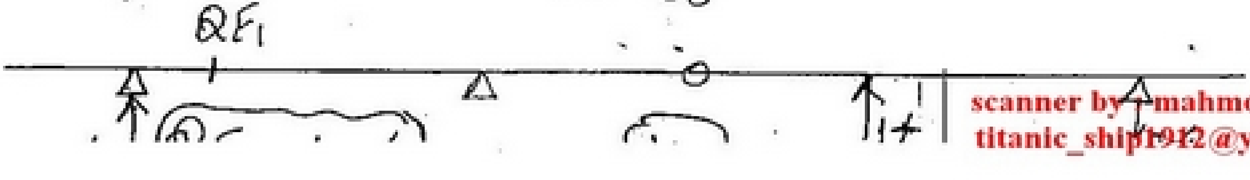


I.L. M_A

*) I.L. Q_E = I.L. Q_{E_0} + Q_{E_1} I.L. y_C



I.L. Q_{E_0}



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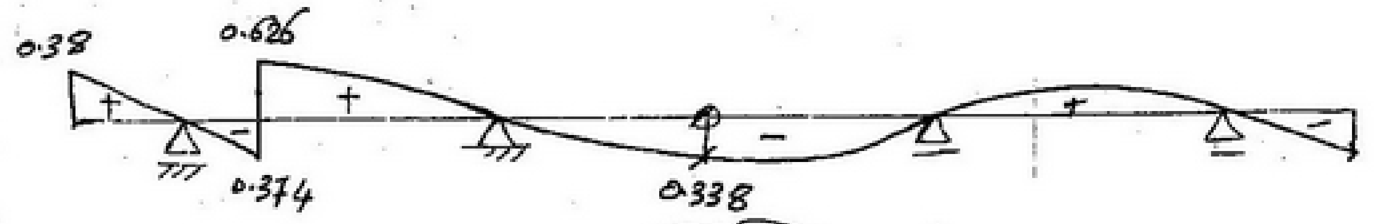
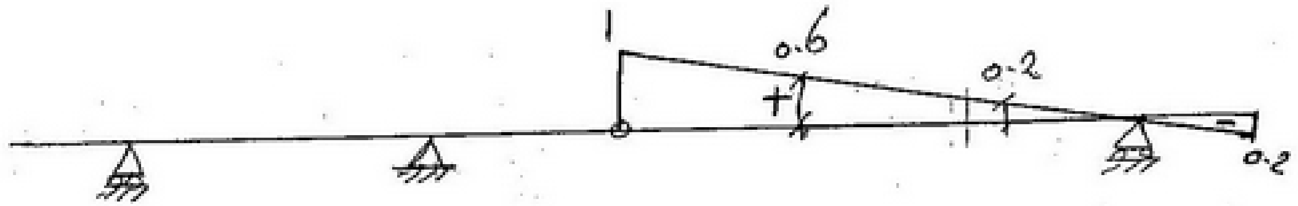
$$\therefore I.L.\,Q_E = I.L.\,Q_{E_0} + 0.4\; I.L.\,y_C$$

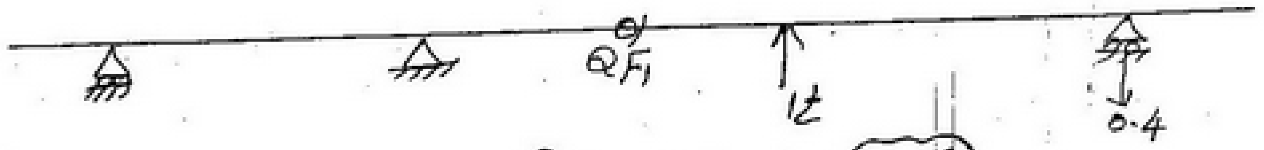


I.L. Q_E

*) $I.L.\,Q_F = I.L.\,Q_{F_0} + Q_{F_1}\; I.L.\,y_C$:

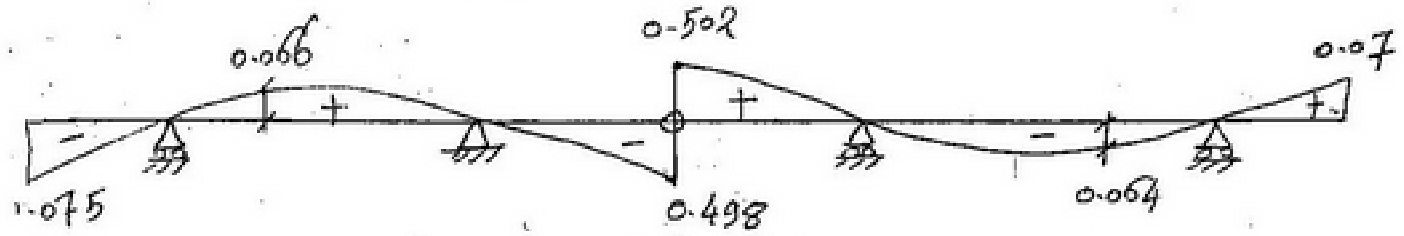


I.L. Q_{F_0}



$$Q_{F_1} = 0.4 - 1 = -0.6$$

$$\therefore I.L.\,Q_F = I.L.\,Q_{F_0} - 0.6\; I.L.\,y_C$$



I.L. Q_F

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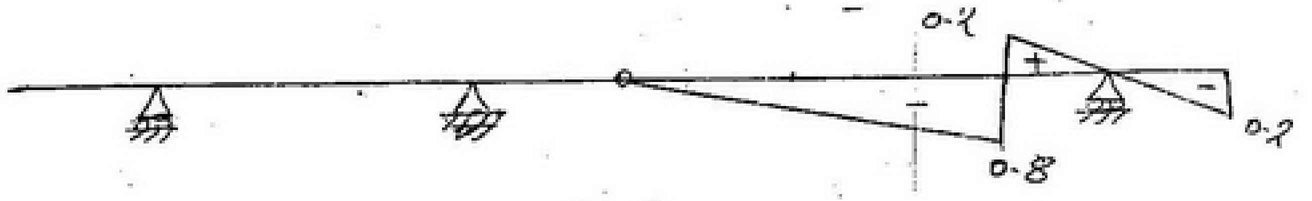
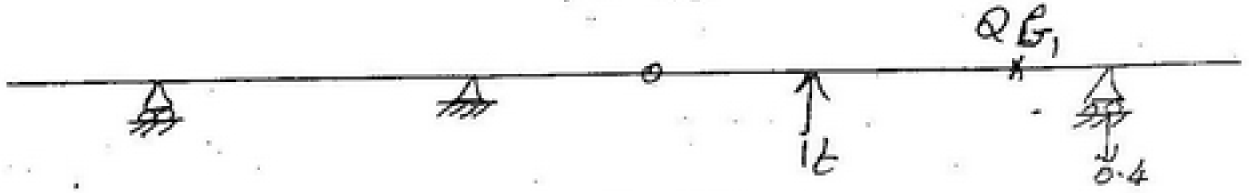
*) $I.L.Q_G = I.L.Q_{G_0} + Q_{G_1}\, I.L.y_C$:

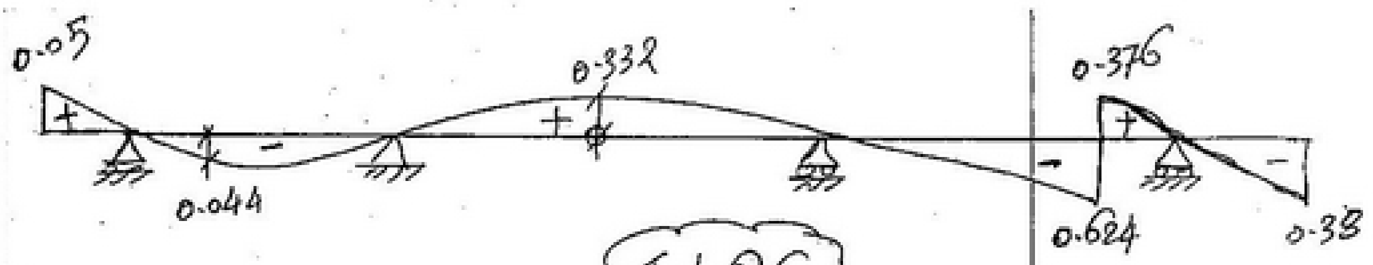


$I.L.Q_{G_0}$



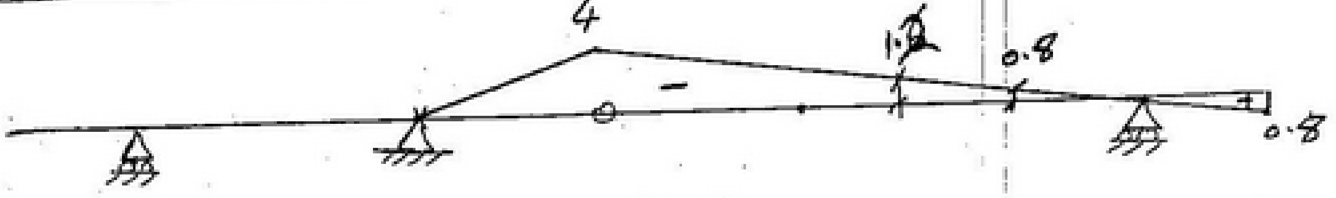
$Q_{G_1} = 0.4$

$\therefore I.L.Q_G = I.L.Q_{G_0} + 0.4\, I.L.y_C$



$I.L.Q_G$

*) $I.L.M_B = I.L.M_{B_0} + M_{B_1}\, I.L.y_C$:



$I.L.M_{B_0}$

$M_{B_1} = 2.4$

$I.L.M_B = I.L.M_{B_0} + 2.4\, I.L.y_C$

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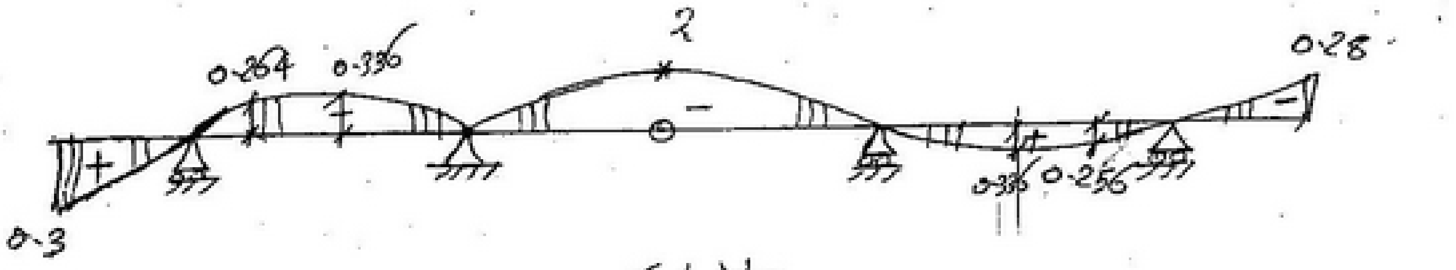
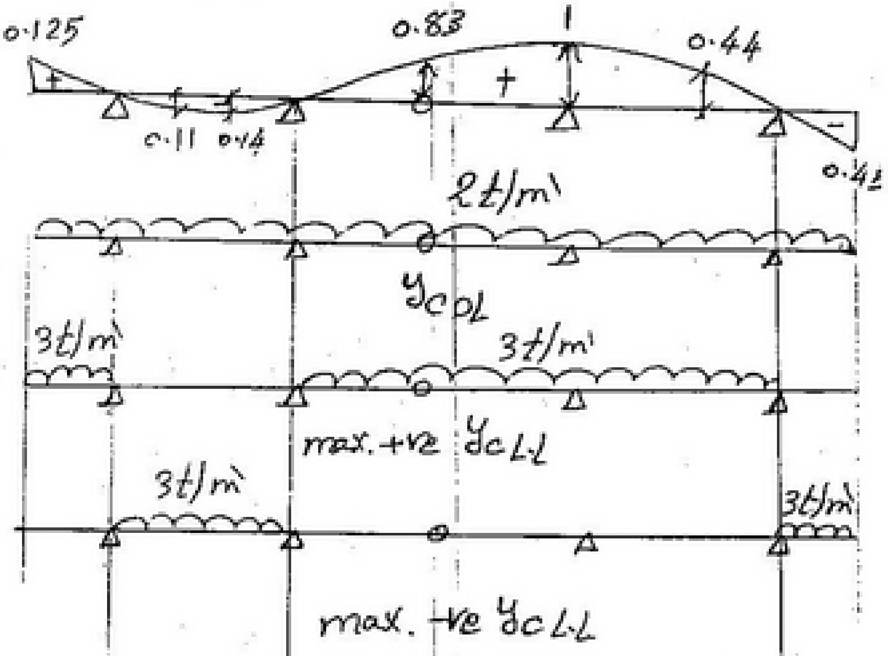


I.L. M_B

***) max. values for y_c :-**



$$y_{c_{D.L}} = 2*\left[\left(\tfrac{1}{2}*2*0.125\right) - \left(\tfrac{2}{3}*0.14*6\right) + \left(\tfrac{2}{3}*1*14\right) - \left(\tfrac{1}{2}*0.45*\right.\right.$$

$$= 16.9\,t$$

$$y_{c_{L.L}}(\text{max. +ve}) = 3*\left[\left(\tfrac{1}{2}*2*0.125\right) + \left(\tfrac{2}{3}*1*14\right)\right] = 28.375$$

$$y_{c_{L.L}}(\text{max. -ve}) = 3*\left[\left(-\tfrac{2}{3}*0.14*6\right) + \left(-\tfrac{1}{2}*0.45*2\right)\right] = -3\,t$$

$$y_{c_{max}} = 16.9 + 28.375 = \boxed{45.275\,t}$$

$$y_{c_{min}} = 16.9 - 3 = \boxed{13.9\,t}$$

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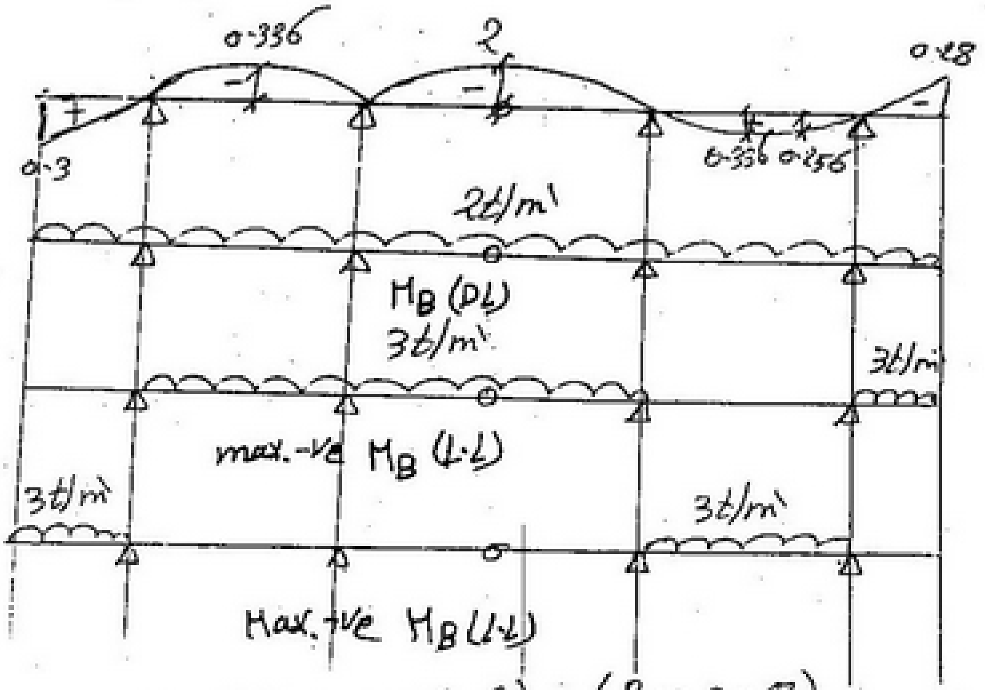
*) max. value of M_B :



$$M_{B(DL)} = 2 * \left[\left(\tfrac{1}{2} * 0.3 * 2\right) - \left(\tfrac{2}{3} * 0.336 * 6\right) - \left(\tfrac{2}{3} * 2 * 8\right) + \left(\tfrac{2}{3} * 0.336 * 6\right) - \left(\tfrac{1}{2} * 0.28 * 2\right) \right] = -21.3\ t.m$$

max. +ve $M_{B(L.L)}$:

$$= 3 * \left[\left(\tfrac{1}{2} * 0.3 * 2\right) + \left(\tfrac{2}{3} * 0.336 * 6\right) \right] = 5\ t.m$$

max. -ve $M_{B(L.L)}$:

$$= 3 * \left[\left(-\tfrac{2}{3} * 0.336 * 6\right) + \left(-\tfrac{2}{3} * 2 * 8\right) + \left(-\tfrac{1}{2} * 0.28 * 2\right) \right]$$

$$= -36.9\ t.m$$

$$\text{max. } M_B = -21.3 - 36.9 = -58.2\ t.m$$

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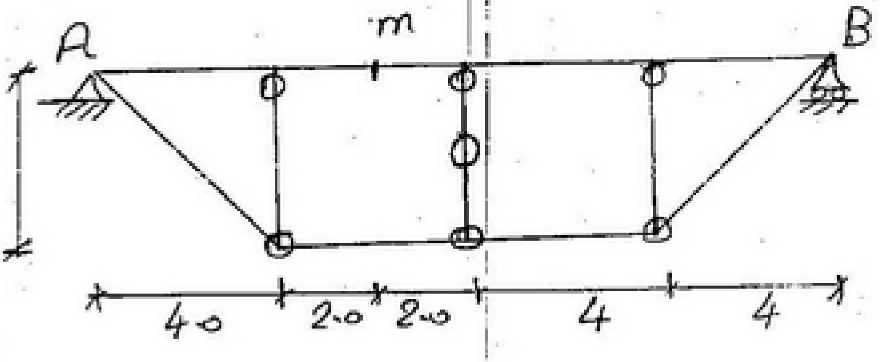
Problem No. 5 :

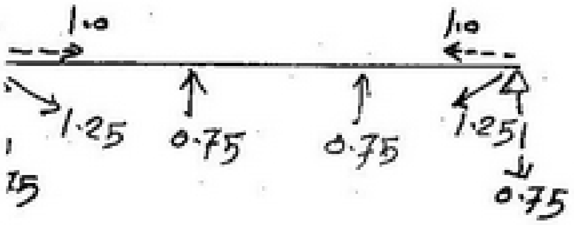
$EA_{link} = 40{,}000$

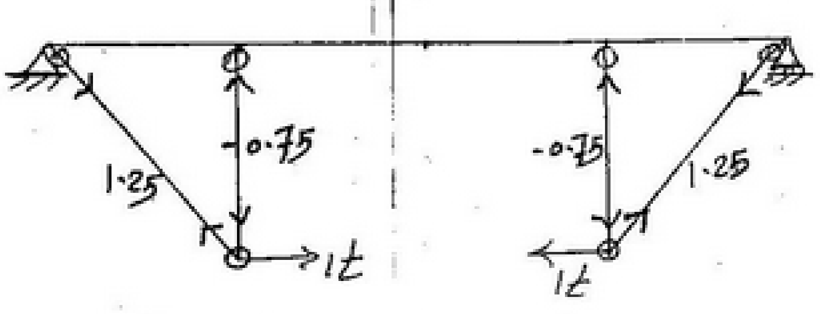
$EA_{beam} = 80{,}000$

$EI = 20{,}000$

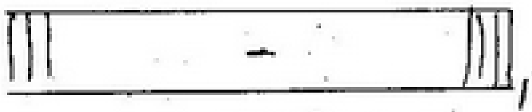


"Solution"

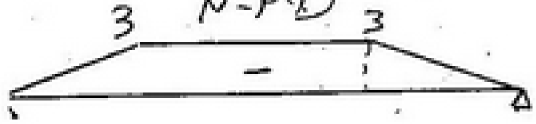




Main system



N.F.D



B.M.D

$$\delta_{11} = \int \frac{M_1^2}{EI} dL + \int \frac{N_1^2}{EA_{beam}} dL + \sum \frac{N_1^2}{EA_{link}} L$$

$$= \frac{1}{20{,}000}\left[\left(\tfrac{1}{2} * 3 * 4 * 2\right) * 2 + (3 * 8 * 3)\right]$$

$$+ \frac{1}{80{,}000}\left[(1 * 16 * 1.0)\right] + \frac{1}{40{,}000}\left[(1.25^2 * 5) * 2 + (0.75^2 * 3) * 2 + (1^2 * 8)\right] = 5.675 * 10^{-3}$$

$$\delta_{11} X_1 = 1.0 \qquad \boxed{X_1 = 176.2}$$

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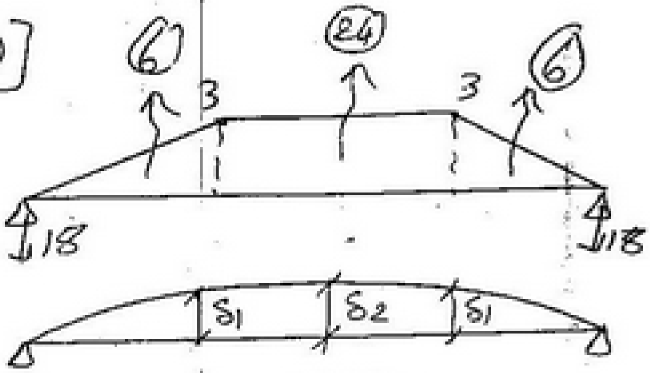
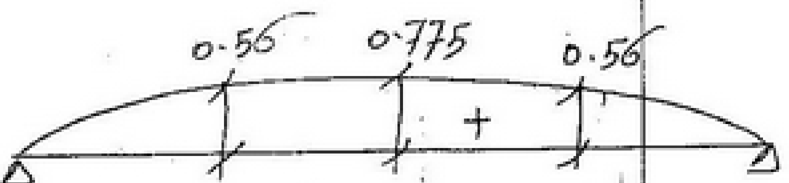
*) I.L. y_B

$$\delta_1 = \frac{1}{20{,}000} * 176.2 \left[\left(6 * \tfrac{4}{3}\right) - (18 * 4) \right]$$
$$= -0.56$$



$$\delta_2 = \frac{1}{20{,}000} * 176.2 \left[\left(6 * \left(\tfrac{4}{3} + 4\right)\right) + (4 * 3 * 2) - (18 * 8) \right]$$
$$= -0.775$$

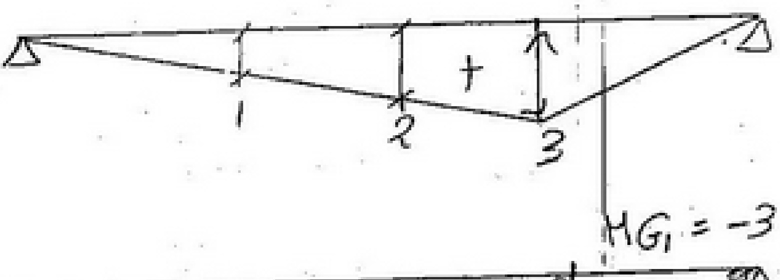
*) I.L. N_{FH}



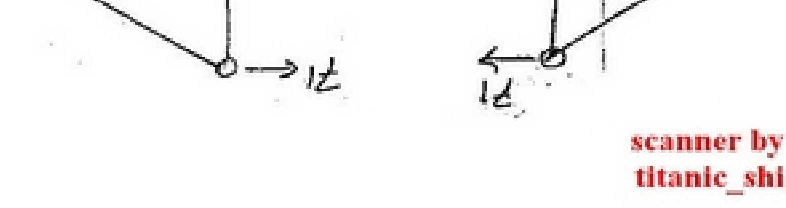
*) I.L. N_{FE}

*) I.L. M_G = I.L. M_{G_0} + M_{G_1} I.L. N_{FH}

I.L. M_{G_0}



$M_{G_1} = -3$



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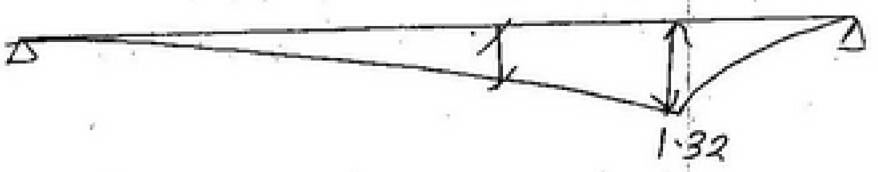
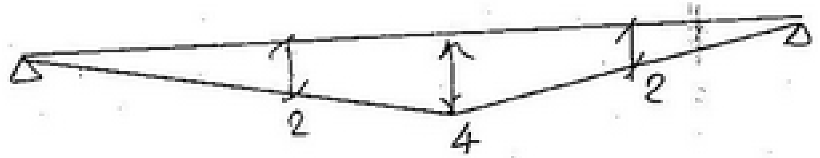
$\therefore I.L.\, M_G = I.L.\, M_{G_0} - 3\, I.L.\, N_{F_H}$



$\therefore I.L.\, M_E = I.L.\, M_{E_0} + M_{E_1}\, I.L.\, N_{F_H}$

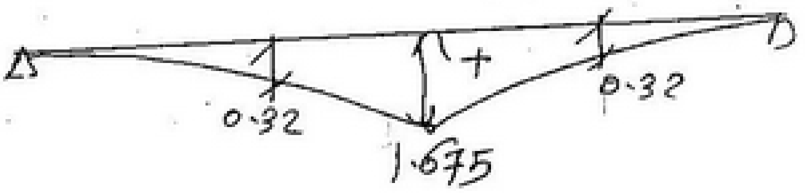
I.L. M_{E_0}



$M_{E_1} = -3\,t.m$

$\therefore I.L.\, M_E = I.L.\, M_{E_0} - 3\, I.L.\, N_{F_H}$

I.L. M_E



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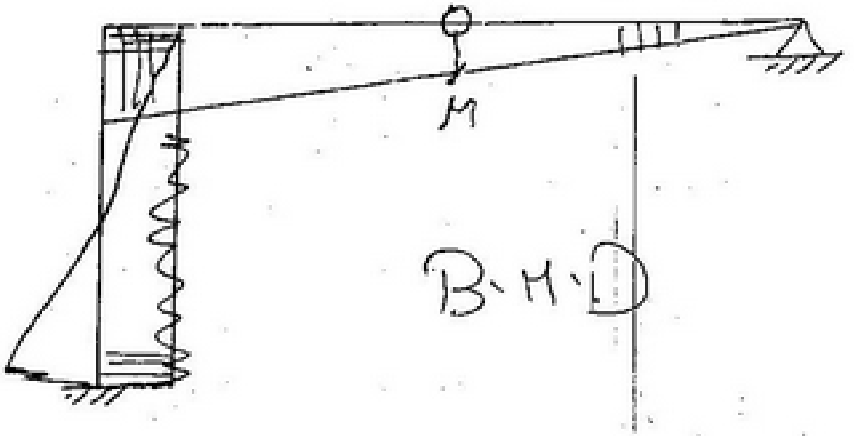
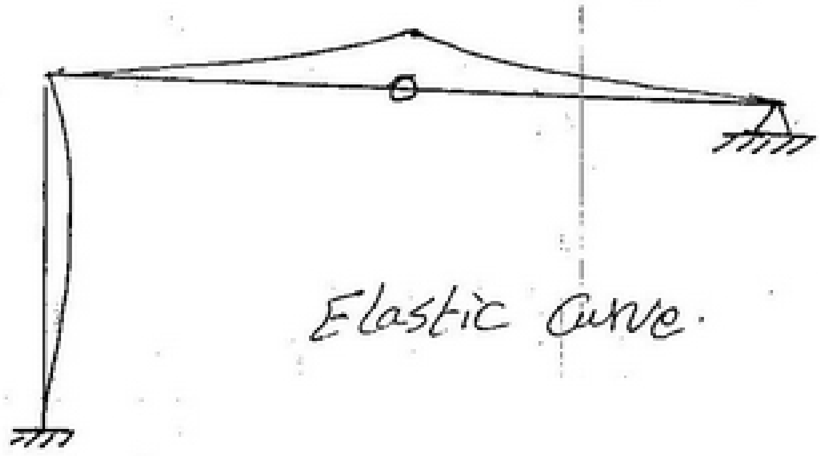
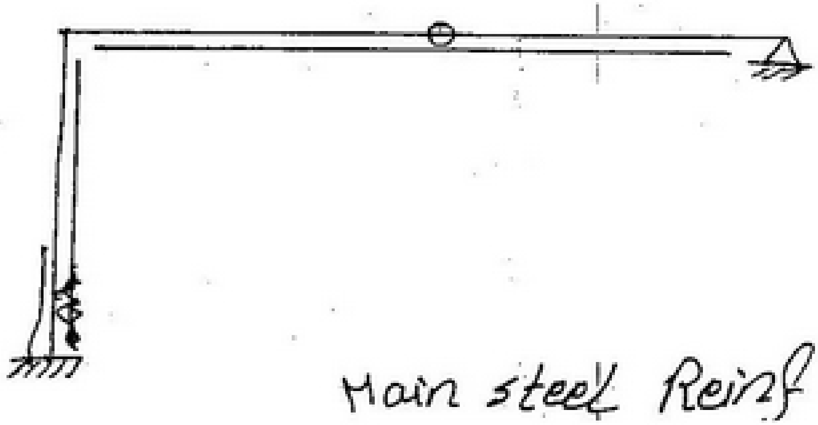
problem No.(6):







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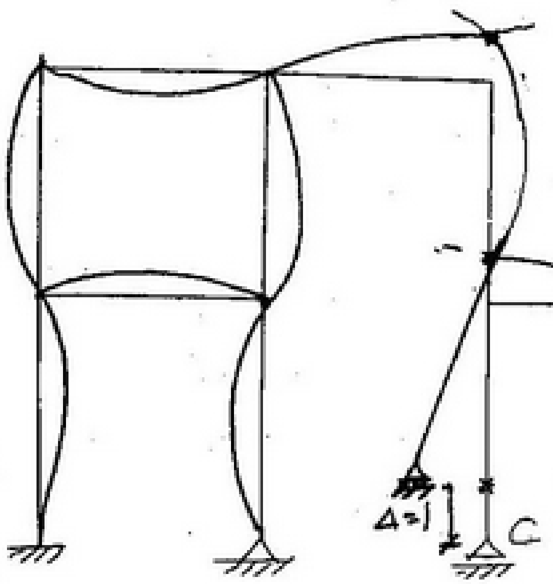
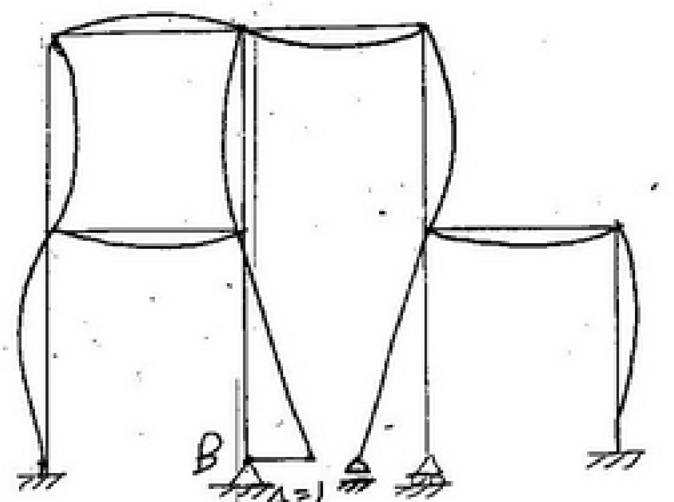
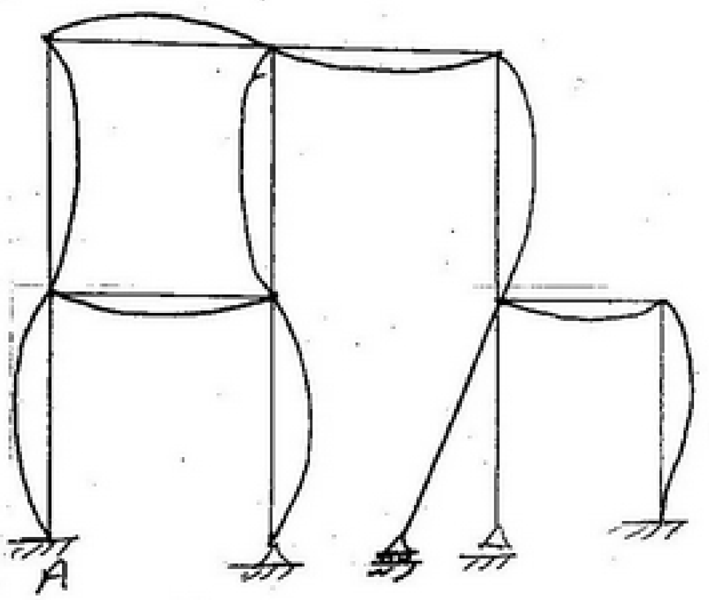


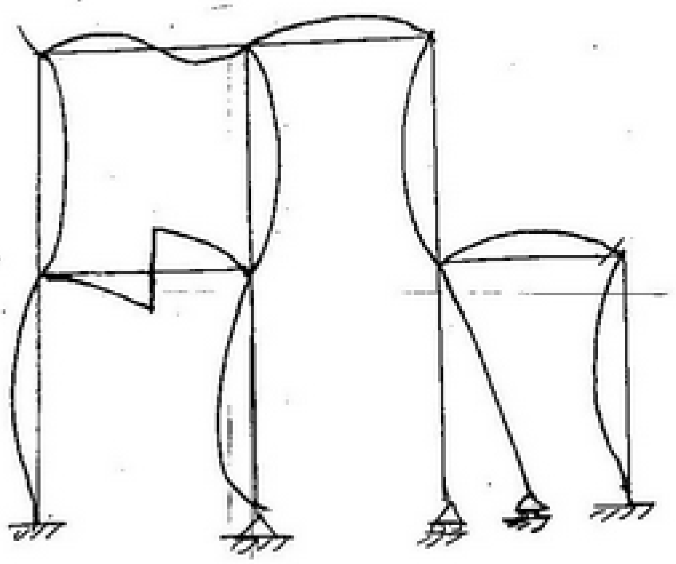
I.L. y_C



I.L. X_B



I.L. M_A



I.L. Q_F

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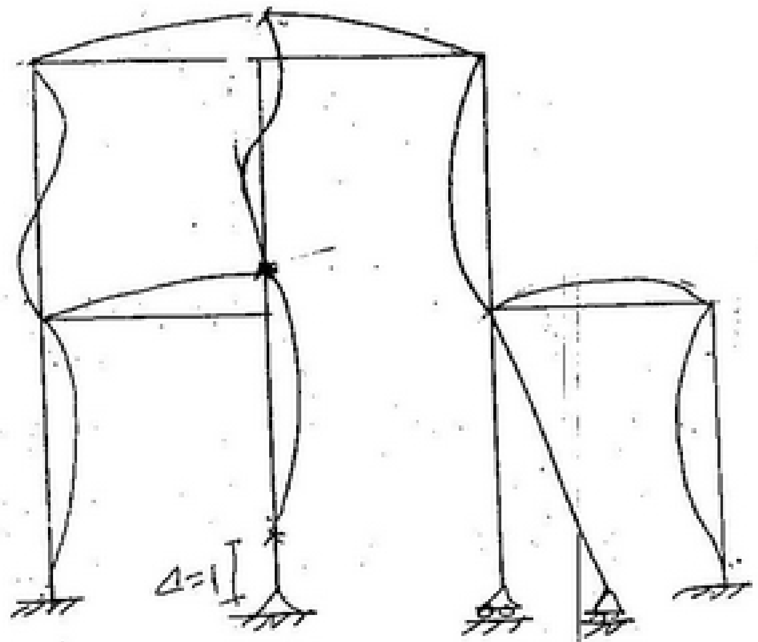
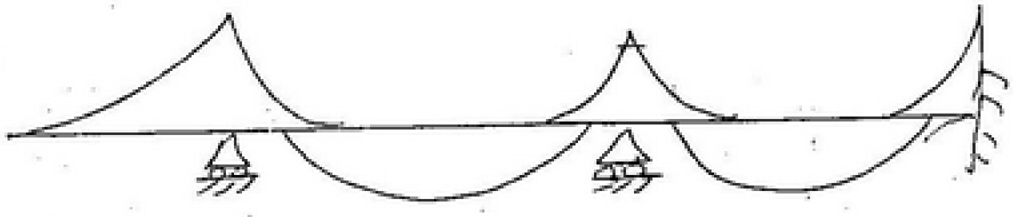


I.L.NG = -I.L.y_B

c) A.B.M :



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Revision

FINAL

STRUCTURE
PART (ح)

الفرقة الثانية - مدني

16

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titanic_ship1912@yahoo.com

Course Name	: Structural Mechanics (2)	Zagazig University Faculty of Engineering	Final Exam		
Course Code	:		Date	:	16-5-2008
Level	: Second Year Civil		Time	:	3 Hour
Department	: Structural Engineering		No. of pages	:	2
Term No.	: 2		No. of Questions	:	6

SOLVE AS YOU CAN

Problem No. (1) *(10 marks)*

Figure (1) shows a statically indeterminate continuous beam, using the three moment equation method, draw the **B.M.D.** and **S.F.D.** . Also, compute the rotation at point **B** due to ;

a) Given loads

b) Vertical settlement at B = 2cm ($EI = 12000\ t.m^2$)

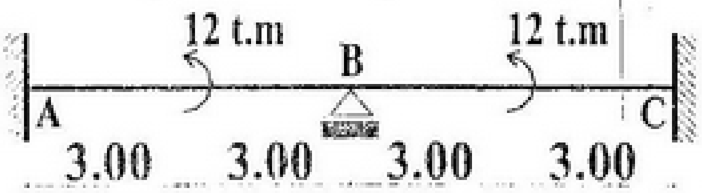

Fig. (1)

Problem No. (2) *(10 marks)*

Figure (2) shows a statically indeterminate structure, using the three moment equation method, draw the **B.M.D.**, **S.F.D.** and **N.F.D.** .Also, compute the vertical deflection at point A due to the given loads.

($EI = 10000\ t.m^2$)

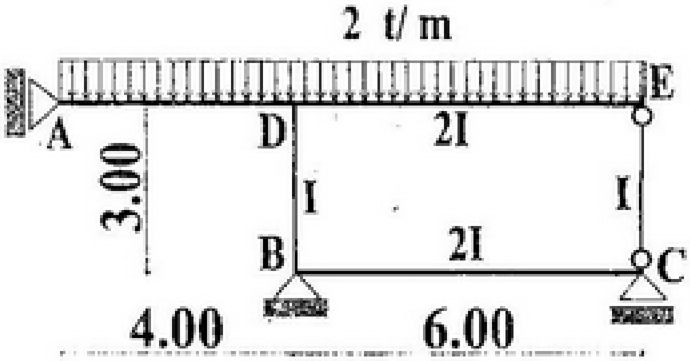

Fig. (2)

Problem No. (3) *(11 marks)*

For the circular cross-section column **BD** (Steel 37) shown in Fig. (3) , determine the maximum permissible load **P** and the factor of safety against buckling.

$E = 2000\ t/cm^2$, $A = 125\ cm^2$,

$I_x = I_y = 9000\ cm^4$

$\sigma_{pl} = 1.2\ t/cm^2$ $\qquad \sigma_{pt} = 1.1\ t/cm^2$

$\sigma_{pb} = \dfrac{6000}{(\lambda)^2}$ for $\lambda = \dfrac{l_b}{i} \geq 104$

$\sigma_{pb} = 1.1 - 0.00005(\lambda)^2$ for $\lambda < 104$

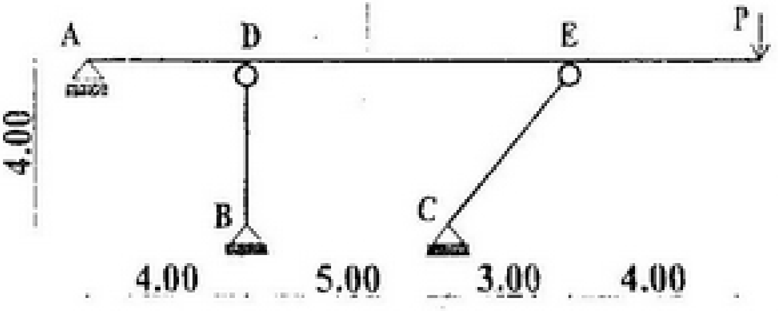

Fig. (3)

اقلب الصفحة من فضلك

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Problem No. (4) *(11 marks)*

For the beam shown in Fig. (4), calculate and draw the influence lines for Y_C, M_A, Q_E, Q_F and M_F. Also, find the maximum values for Y_C and M_F due to 2t/m dead load and 3 t/m live load

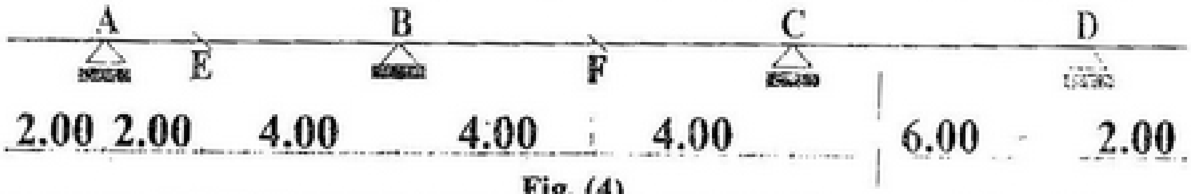

Fig. (4)

Problem No. (5) *(12 marks)*

For the shown statically indeterminate trussed beam (Fig. 5), introduce the influence lines for Y_A, M_B, Q_m and M_m.

$EI_b = 20000$ t.m^2 **$EA_b = 80000$ t** **$EA_{links} = 40000$ t**

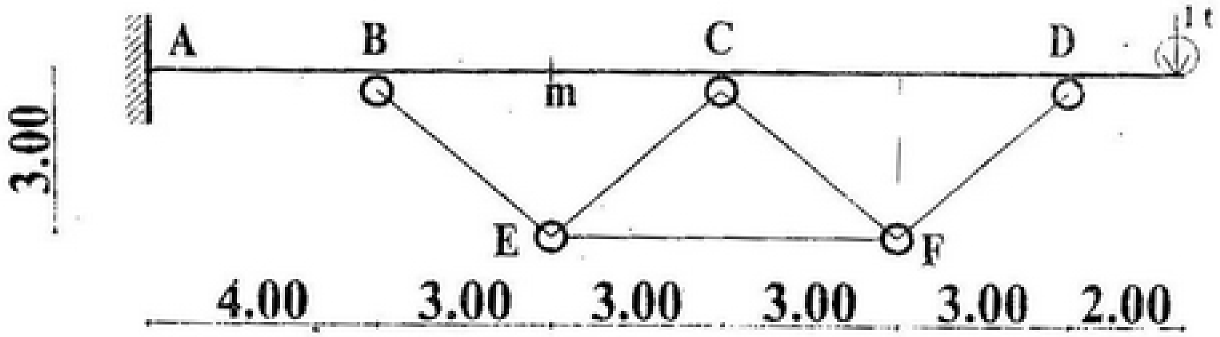

Fig. (5)

Problem No. (6) *(12 marks)*

a) For the structure shown in figure (6-a), without calculations, sketch S.F.D, N.F.D., B.M.D. , the elastic curve, and the main steel reinforcement.

b) For the structure shown in figure (6-b), without calculations, sketch the influence lines for Y_C, N_K, N_P, N_n, M_M and Q_L.

Fig. (6-a)

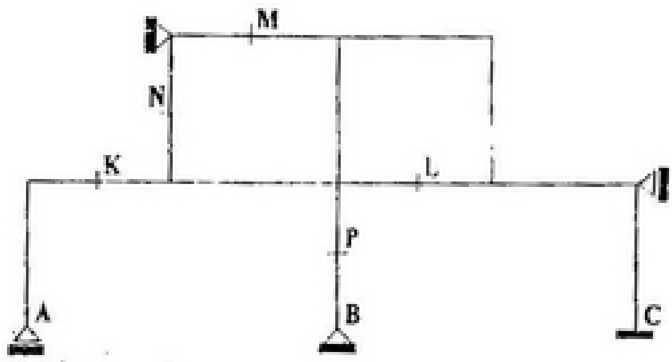

Fig. (6-b)

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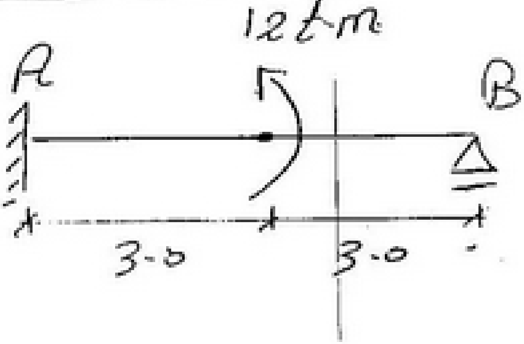
Q -1-

a) given loads : (Anti-symmetric)

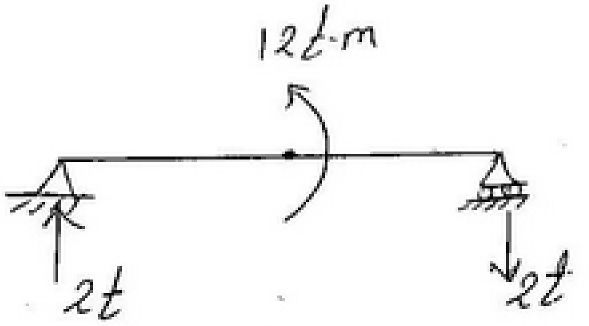
1) unknowns

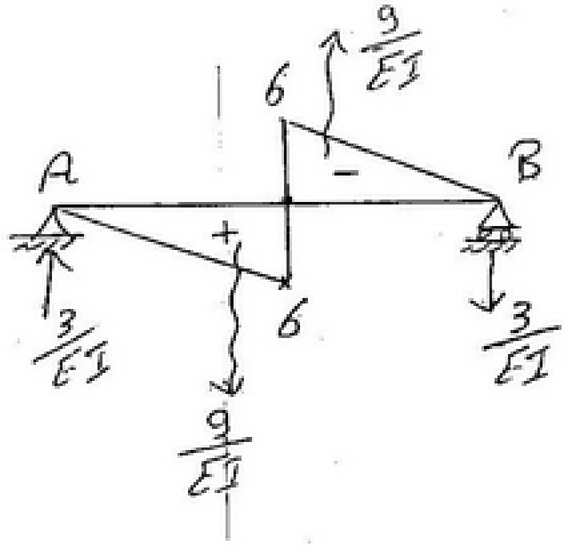
$M_A = ??$

$M_B = 0$



2) Elastic reaction





$$r_A = \frac{3}{EI}$$

3) Apply 3-M Equation :

$$0 + 2M_A\left(0 + \frac{6}{I}\right) + M_B\left(\frac{6}{I}\right) = -6 r_A E$$

($M_B \to 0$)

$$2M_A\left(\frac{6}{I}\right) = -6 * \frac{3}{EI} E$$

$$M_A = -1.5 \ t.m$$

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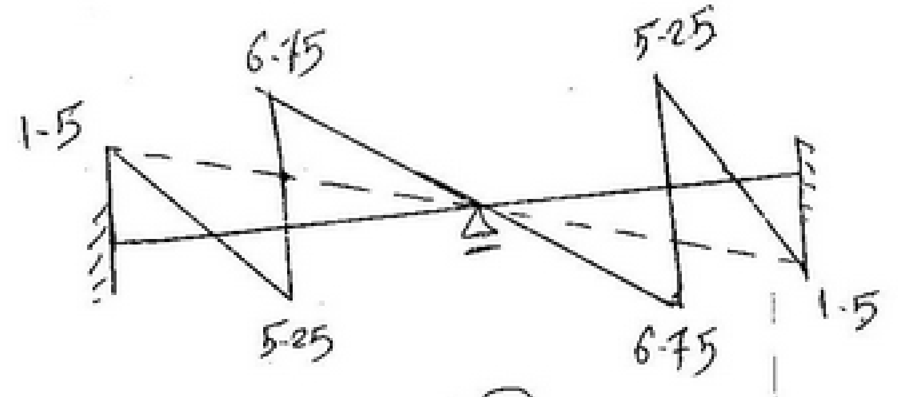
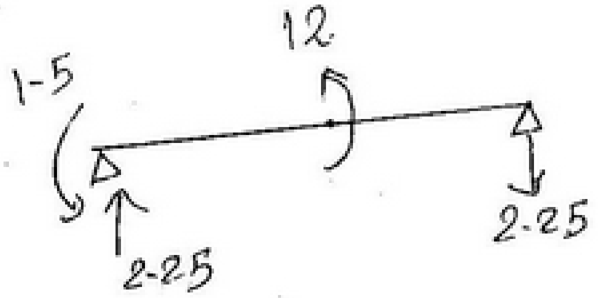
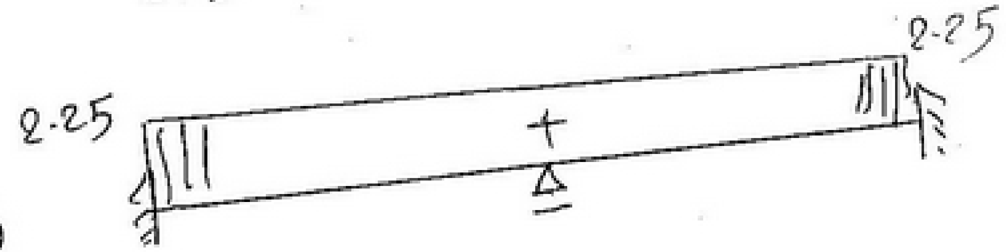
M



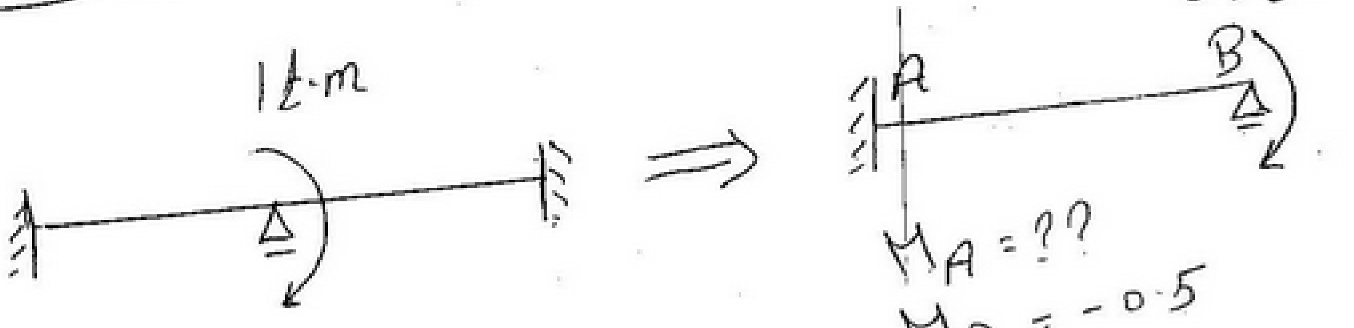
B.M.D





S.F.D

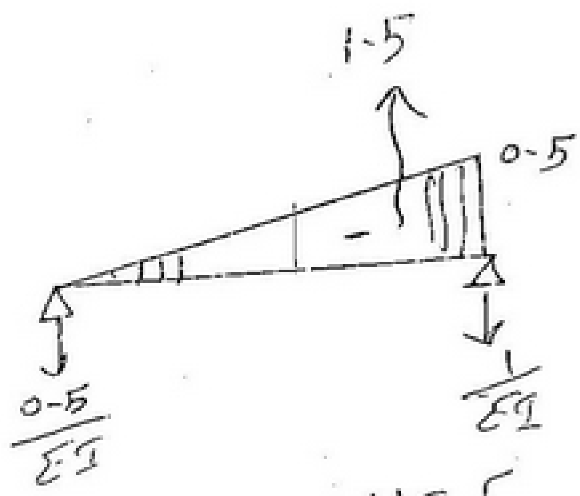
For Rotation at (B) :-



$M_A = ??$

$M_B = -0.5$

$$Y_A = \frac{-0.5}{EI}$$



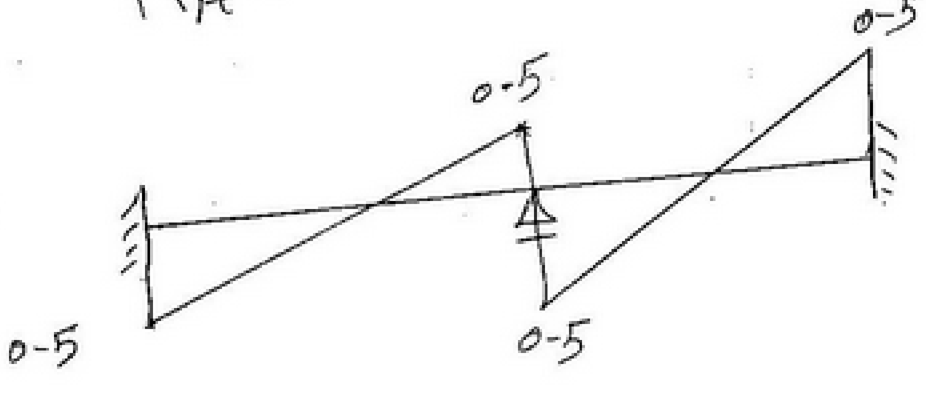
$$0 + 2M_A\left(0 + \frac{6}{I}\right) + M_B\left(\frac{6}{I}\right) = -6 Y_A E$$

$$2M_A\left(\frac{6}{I}\right) + -0.5\left(\frac{6}{I}\right) = -6 * \frac{-0.5}{EI} E$$

$$12M_A - 3 = +3$$

$$M_A = 0.5 \text{ t.m}$$

M_o



$$\theta_B = \int \frac{M M_o}{EI} dL$$

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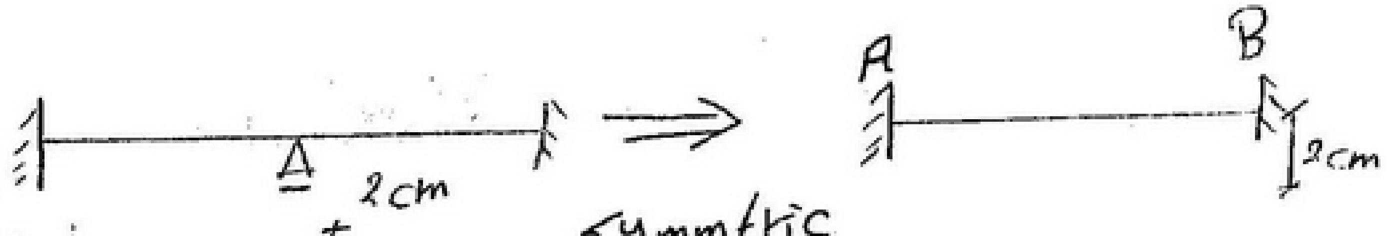
) due to settlement $EI = 12,000\ t.m^2$



symmtric

M_A ??

M_B ??

at support (A)

$$2M_A\left(0+\frac{6}{I}\right) + M_B\left(\frac{6}{I}\right) = 6E\left(0+\frac{0-2}{600}\right)$$

$$2M_A\left(\frac{6}{I}\right) + M_B\left(\frac{6}{I}\right) = 6E\left(\frac{-2}{600}\right)$$

$$2M_A + M_B = EI\left(\frac{-2}{600}\right) = -40 \rightarrow (1)$$

at support (B)

$$M_A\left(\frac{6}{I}\right) + 2M_B\left(\frac{6}{I}+0\right) + 0 = 6E\left(\frac{2-0}{600}+0\right)$$

$$M_A + 2M_B = 40 \rightarrow (2)$$

(2) ، (1) نحل المعادلتين

$$2M_A + M_B = -40$$

$$-2 \times \quad M_A + 2M_B = 40$$

$$-2M_A - 4M_B = -80$$

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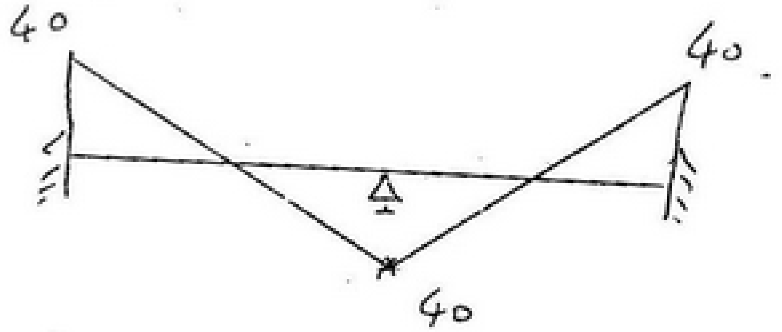
$-3M_B = -120$

$M_B = 40\ t\cdot m$

$M_A = -40\ t\cdot m$



Note $\frac{6EI}{L^2}\Delta = \frac{6 * 12000}{36} * 0.02 = 40\ t\cdot m$

θ_B = zero From symmetric

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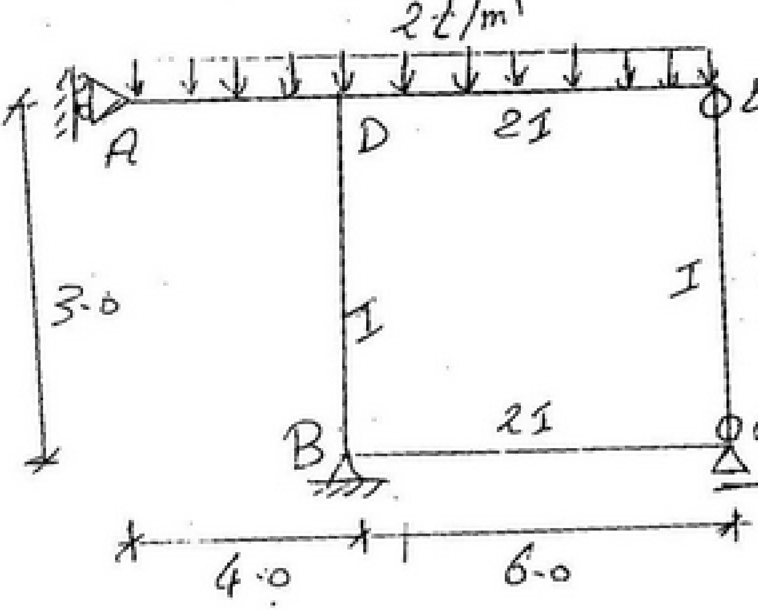
Q -2-

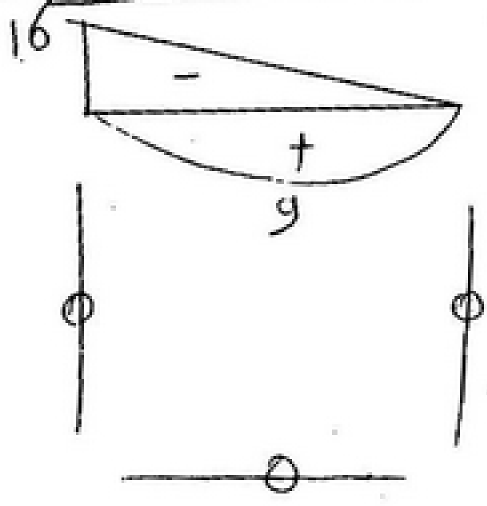


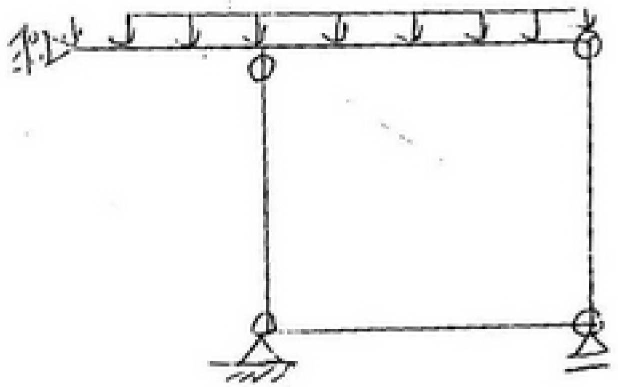
1 unknowns :

M_B ??

M_D ??

2 Elastic reaction :





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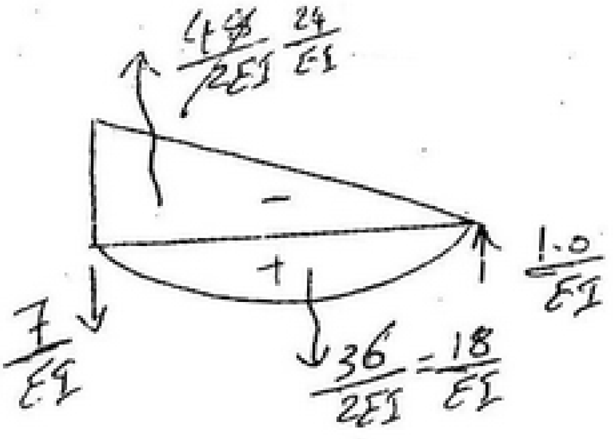

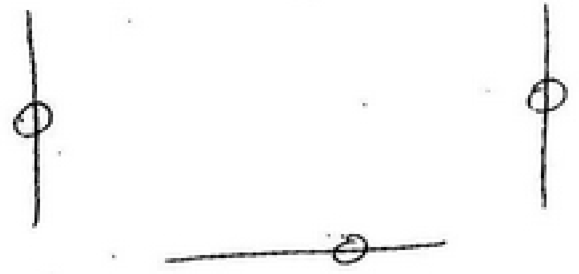

$r_B = 0$

$r_D = \frac{-7}{EI}$

3) Apply 3-M Equation :

$$M_C\left(\frac{6}{2I}\right) + 2M_B\left(\frac{6}{2I} + \frac{3}{I}\right) + M_D\left(\frac{3}{I}\right) = -6 r_B E$$

$M_C \to 0$

$$2M_B\left(\frac{6}{I}\right) + M_D\left(\frac{3}{I}\right) = -6 \times 0$$

$$12M_B + 3M_D = 0$$

$$4M_B + M_D = 0 \longrightarrow (1)$$

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$$M_B\left(\frac{3}{I}\right) + 2M_D\left(\frac{3}{I} + \frac{6}{2I}\right) + M_E\left(\frac{6}{2I}\right)$$

$$= -6\, r_{DE}$$

$$M_B\left(\frac{3}{I}\right) + 2M_D\left(\frac{6}{I}\right) + 0 = -6 \times \frac{-7}{2I}$$

$$3M_B + 12M_D = 42 \longrightarrow (2)$$

بحل المعادلات ① ، ②

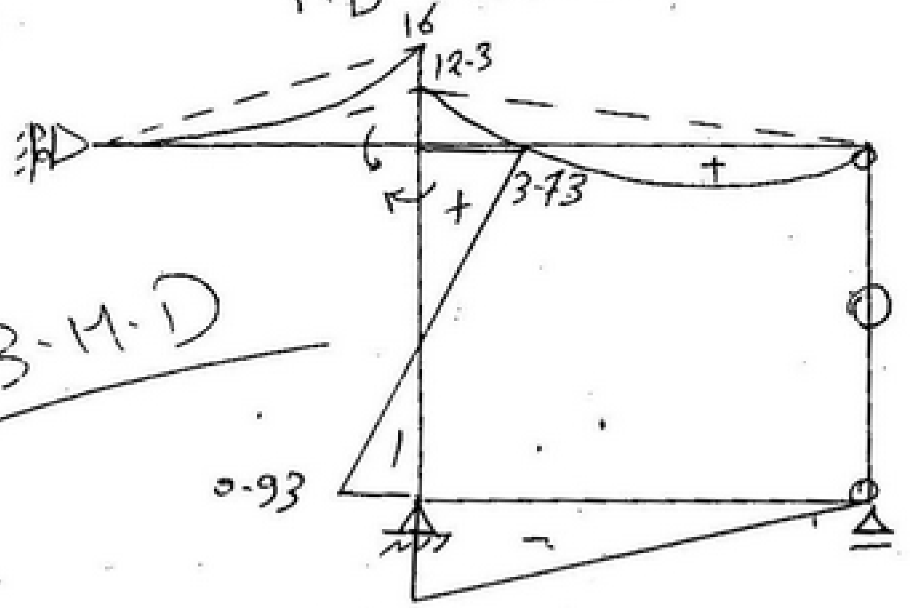
$$-4 \times \quad 4M_B + M_D = 0 \quad (-16M_B - 4M_D)$$

$$M_B + 4M_D = 14$$

$$-15M_B = 14$$

$$M_B = -0.93\ t.m$$

$$M_D = 3.73\ t.m$$



B.M.D

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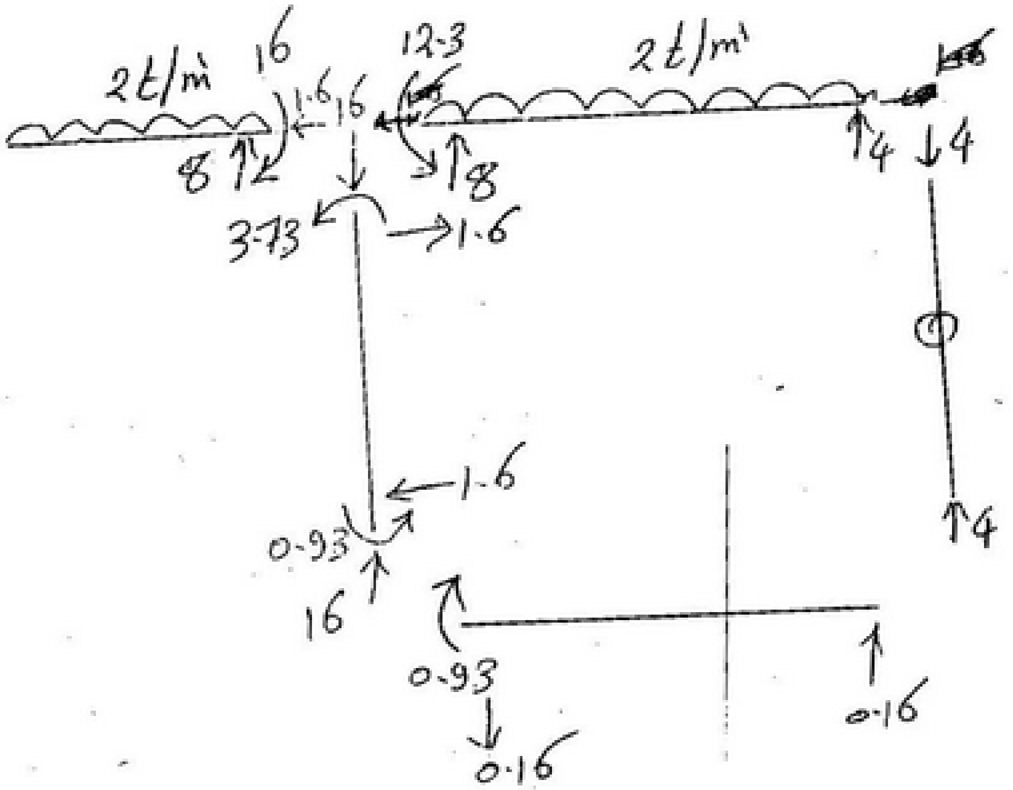
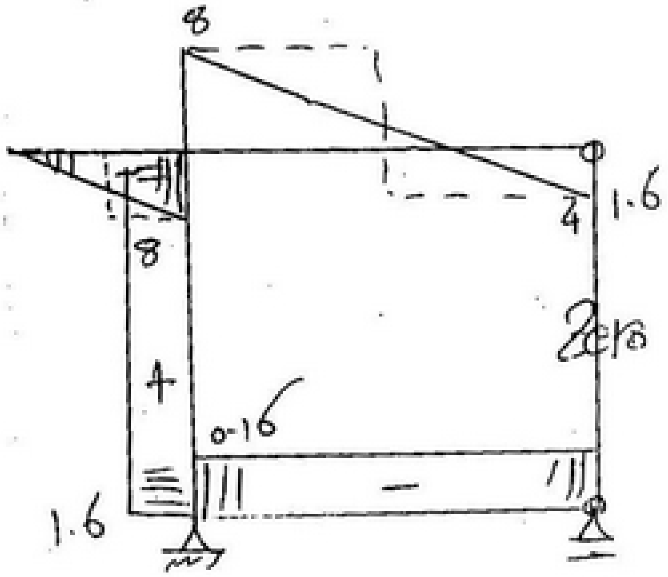
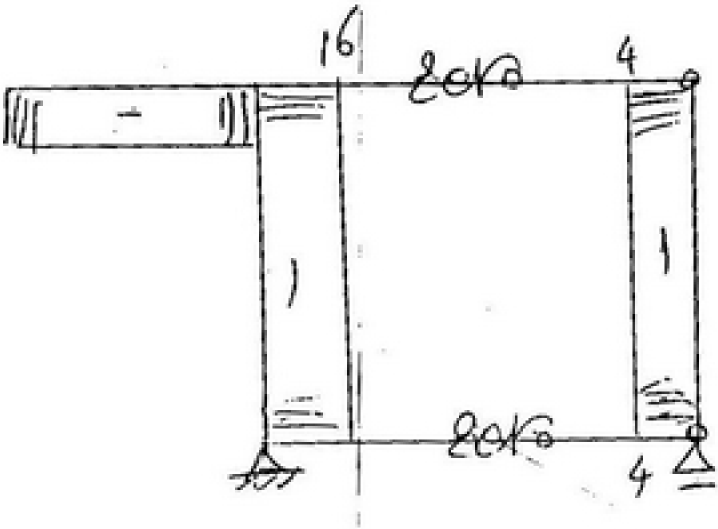




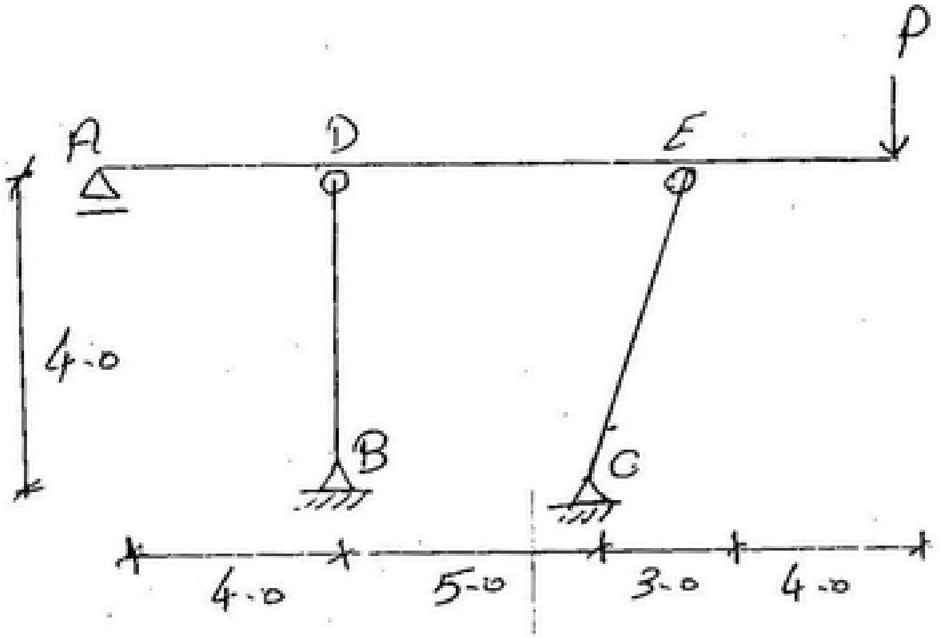
S-F-D



N-F-D

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Q. -3-



For Column BD :

$l_b = L = 400 \text{ cm}$ (hinged - hinged)

$i_{min} = \sqrt{\frac{9000}{125}} = 8.48$

$\lambda = \frac{l_b}{i_{min}} = 47.17 < 104$

$\sigma_{pb} = 1.1 - 0.00005\lambda^2 = 0.988 \ t/cm^2$

$P_{pb} = \sigma_{pb} * A = 123.6 t$

$K = \frac{\sigma_{pc}}{\sigma_{pb}} = \frac{1.1}{0.988} = 1.11$

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* straining action :

$M_x = 0$

$M_y = 0$

$N = 4P$

$$\sigma_{max} = \frac{N}{A} K \ngtr \sigma_{pc}$$

$$1.1 = \frac{4P}{125} * 1.11$$

$$P \simeq 31\, t$$

$$P_{cr} = \frac{\pi^2 E I_{min}}{(l_b)^2} = \frac{\pi^2 * 2000 * 9000}{(400)^2} = 1110.33$$

$$n = \frac{P_{cr}}{P_{pb}} = \frac{1110.33}{123.6} = 8.98$$

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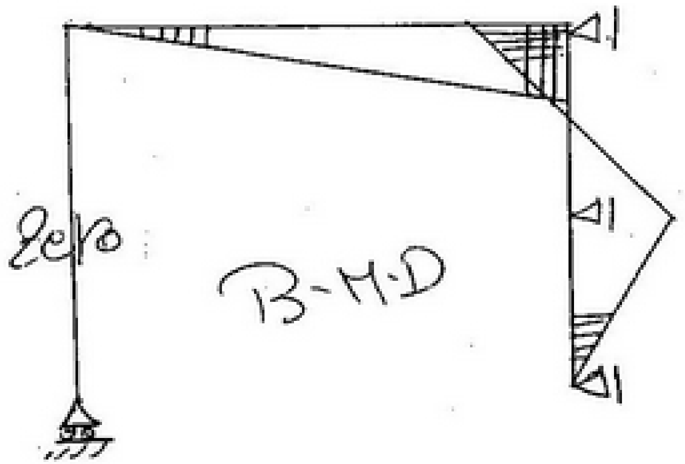
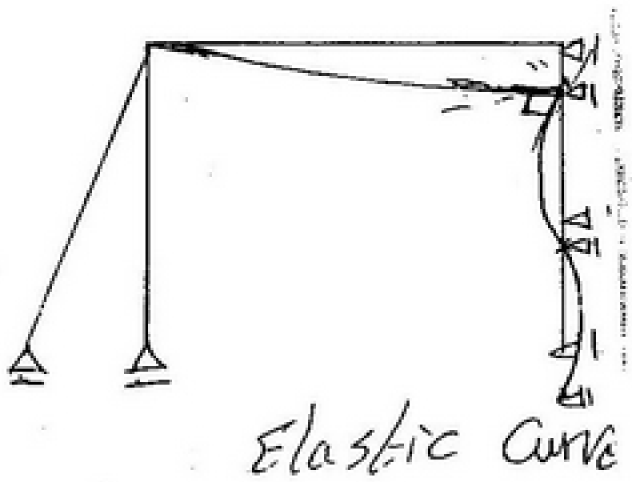
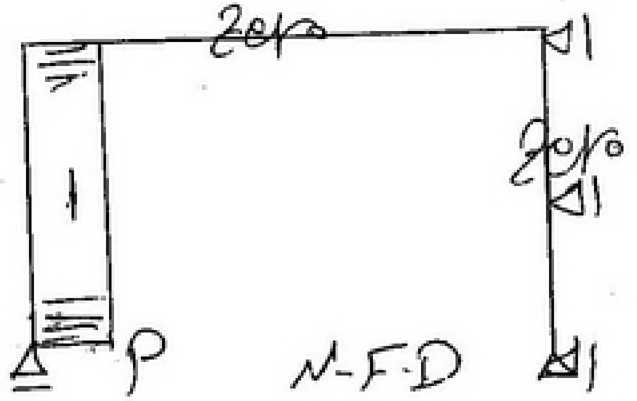
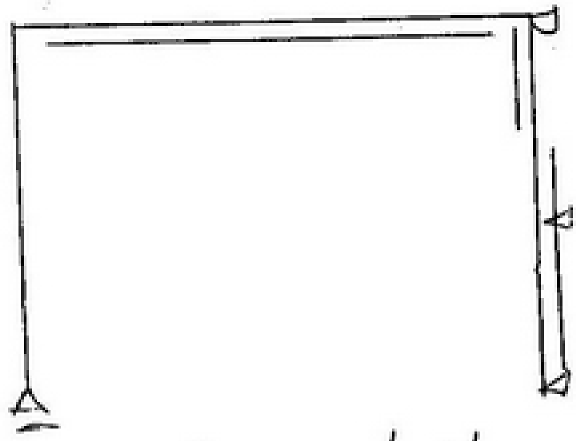
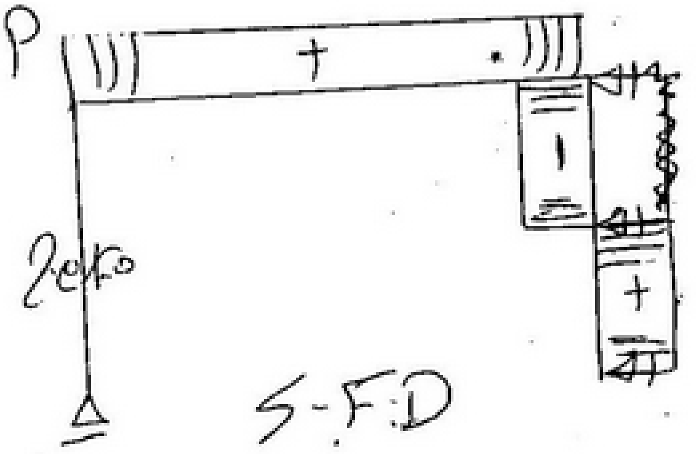
Q - 6 - sketch











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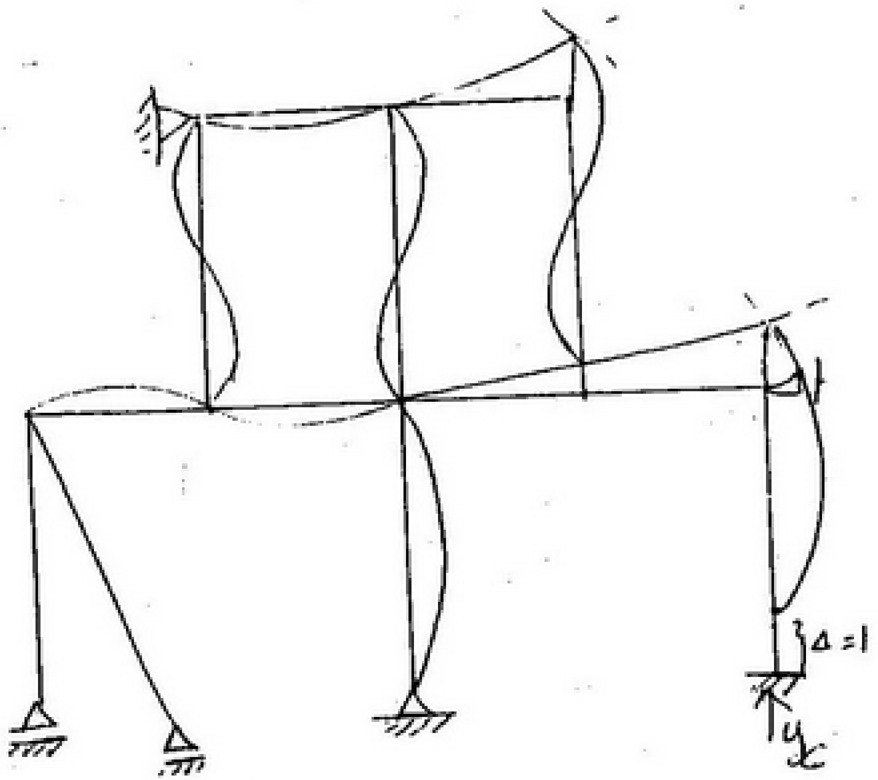
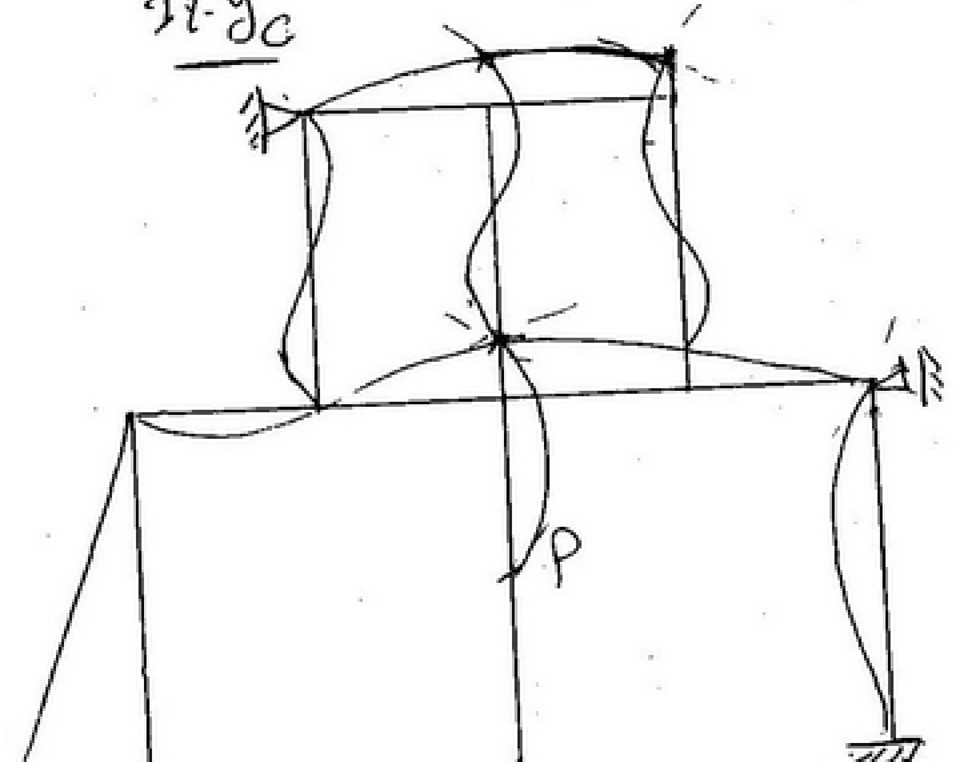


I.L Nk = zero

I.L-Yc



I.L-Np

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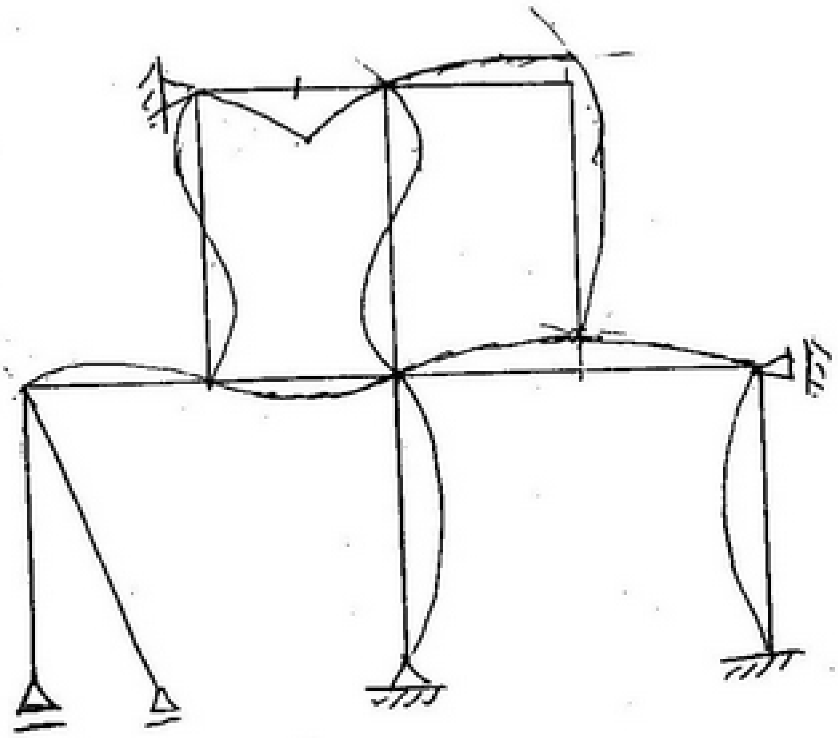
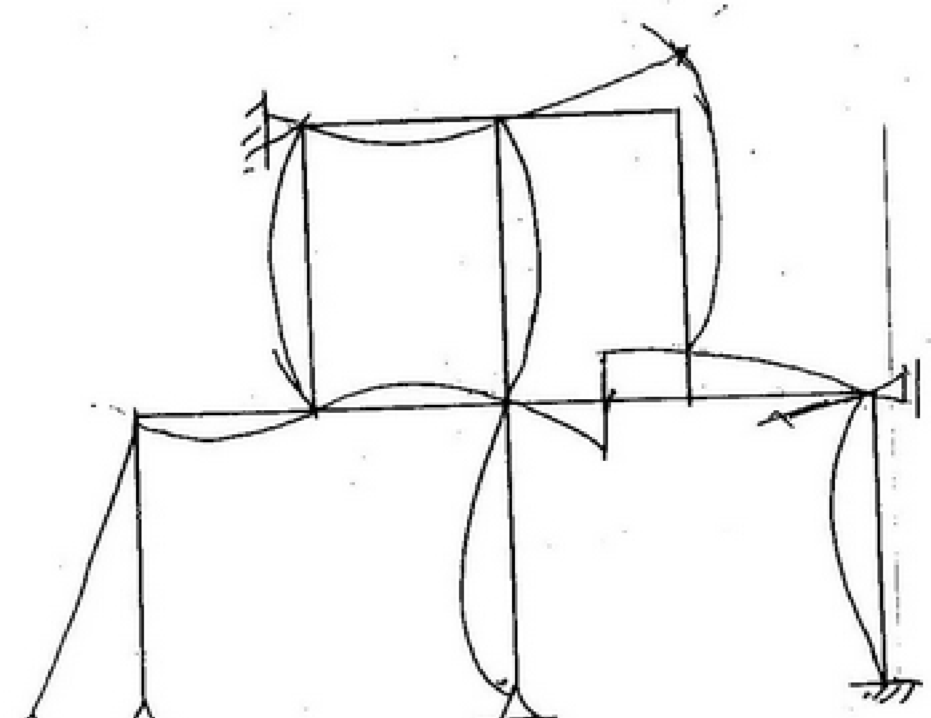


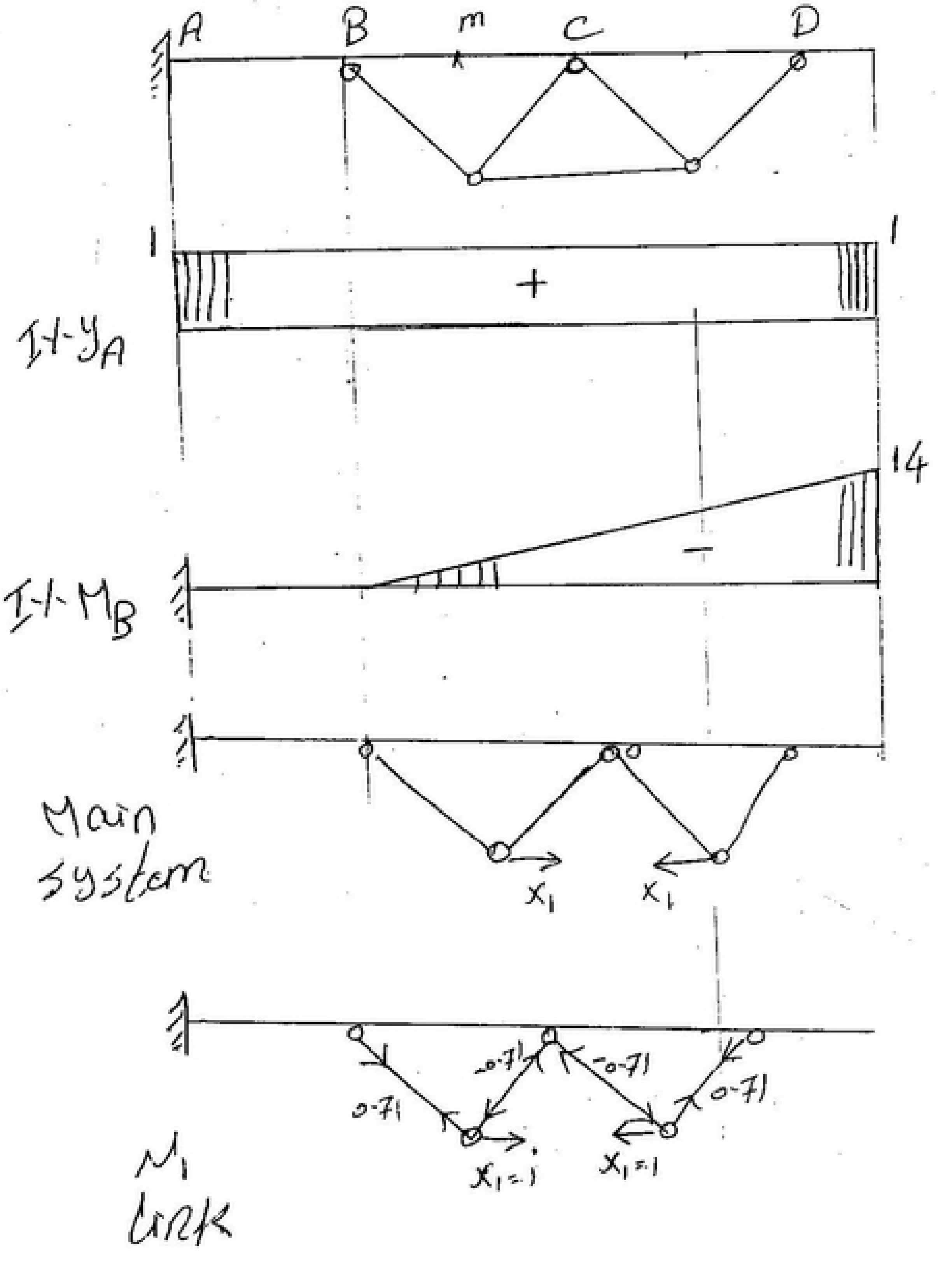
I.L-Mm



I.L-QL

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

Q.No(5) :-



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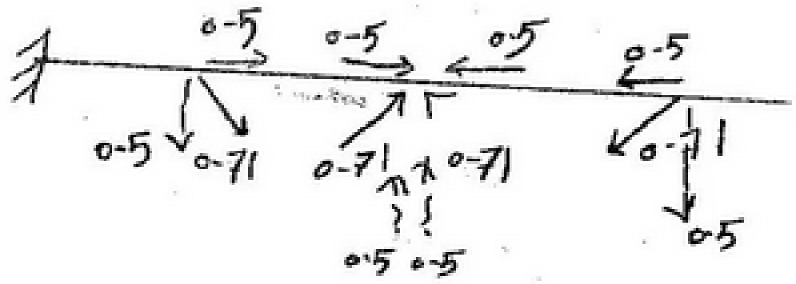
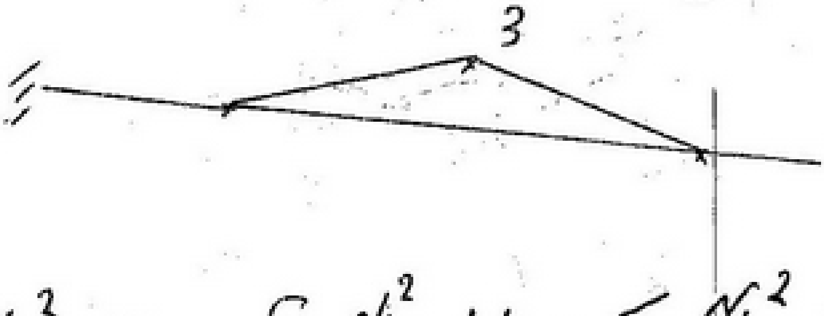


M Beam

M Beam



$$\delta_{11} = \int \frac{M_1^2}{EI} dL + \int \frac{N_1^2}{EA} dL + \sum \frac{N_1^2}{EA} L$$

$$= \frac{1}{EI}\left[\left(\frac{3 \times 3 \times 12}{3}\right)\right] + \frac{1}{EA}\left[(0.5 \times 12 \times 0.5)\right]$$

$$+ \frac{1}{EA}\left[(0.71^2 \times 3\sqrt{2}) \times 4 + (1^2 \times 6)\right] = 2.2 \times 10$$

$$\delta_{11} X_1 = 1.0$$

$$X_1 = 454.3\,t$$

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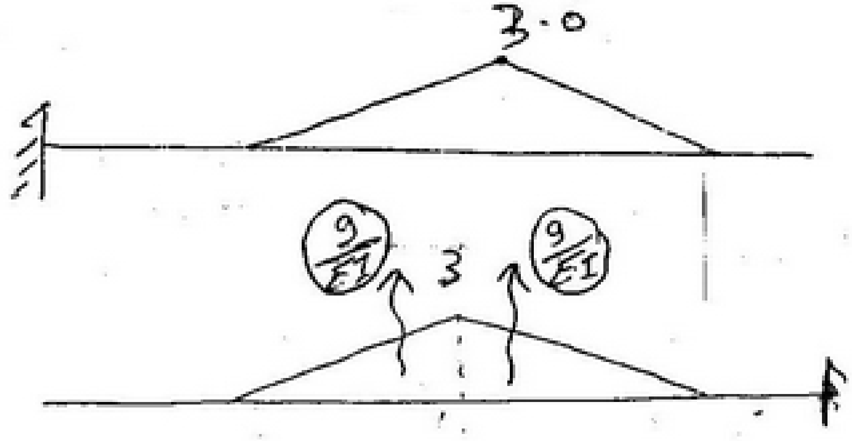
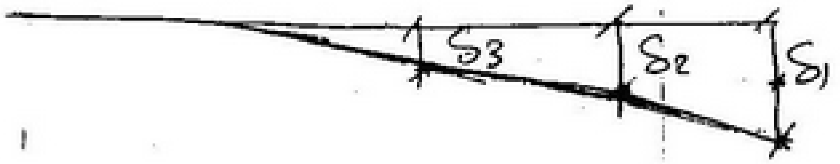


I.L.F₁



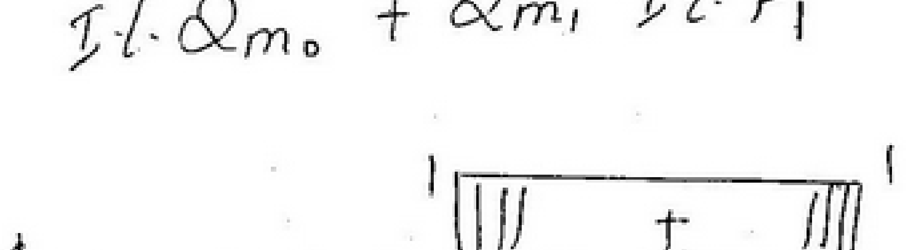
$$\delta_1 = \frac{1}{EI}\left[(9*6) + (9*10)\right] * 454.3 = 3.27$$

$$\delta_2 = \frac{1}{EI}\left[(9*4) + (9*8)\right] * 454.3 = 2.45$$

$$\delta_3 = \frac{1}{EI}\left[(9*2)\right] * 454.3 = 0.4$$

$$I.L.Q_m = I.L.Q_{m_0} + Q_{m_1}\, I.L.F_1$$

I.L.Q_{m_0}



$$Q_{m_1} = -0.5$$

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3 moment equation

- حدد العزم عند كل الركائز وحدد المجهول
- حرر العزم المجهول عن طريق وضع Intermediate hinge
- ارسم العزم عند كل ركيزه
- حول العزم لـ احمال مرنه عن طريق القسمة على EI
- اوجد رد الفعل عند الركيزه غير معلومة العزم
- طبق في المعادله

$$M_A\left(\frac{L_{AB}}{I_{AB}}\right) + 2M_B\left(\frac{L_{AB}}{I_{AB}}+\frac{L_{BC}}{I_{BC}}\right) + M_C\left(\frac{L_{BC}}{I_{BC}}\right) = -6r_B$$

★ في حالة Fixed

نتخيل وجود ركيزه A_o عندها العزم = صفر و Inertia = ∞

★ في حالة الهبوط

$$M_A(L_{AB}) + 2M_B(L_{AB}+L_{BC}) + M_C(L_{BC}) = 6EI\left[\frac{\delta_B-\delta_A}{L_{AB}}+\frac{\delta_B-\delta_C}{L_{BC}}\right]$$

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$$P_{cr} = \frac{\pi^2 E I_{min}}{(L_b)^2} \qquad \delta_{cr} = \frac{P_{cr}}{A}$$

hinge - hinge $L_b = L$ hinge - fixed $L_b = 0.7 L$

fixed - fixed $L_b = 0.5 L$ fixed - free $L_b = 2 L$

معامل النحافة $\lambda = \frac{L_b}{i}$ $i = \sqrt{\frac{I_{min}}{A}}$

$\boxed{\delta_{Pb}}$

steel 37

$\lambda \geq 104$ $\delta_{Pb} = 6000 / \lambda^2$

$\lambda \leq 104$ $\delta_{Pb} = 1.1 - 0.00005\ \lambda^2$

$\delta_{Pc} = 1.1$

steel 44

$\lambda \geq 96$ $\delta_{Pb} = 6000 / \lambda^2$

$\lambda < 96$ $\delta_{Pb} = 1.3 - 0.00007\ \lambda^2$

$\delta_{Pc} = 1.3$

steel 52

$\lambda \geq 85$ $\delta_{Pb} = 7500 / \lambda^2$

$\lambda < 85$ $\delta_{Pb} = 1.4 - 0.000065\ \lambda^2$

$\delta_{Pc} = 1.4$

$$\delta_{Pb} = \frac{P_{Pb}}{A}$$

$n = \delta_{cr} / \delta_{Pb}$ factor of safty

$K = \delta_{Pc} / \delta_{Pb}$ Coff of Buckling

$\delta = \frac{P}{A} \times K \ngtr \delta_{Pc}$ Max Labor stresses

$$\delta = \frac{P}{A} \cdot K + \frac{M_x}{I_x} \cdot y + \frac{M_y}{I_y} \cdot x$$

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I.L → beam

١- نفصل المحدد و نرسمه

٢- نختار main sys للغير محدد

٣- نرسم B.M.D نتيجة القوة على main sys

٤- نحول conj

٥- نوجد M عند كل النقاط

٦- نقسم كل M على التي وضع القوة عندها على main sys

فنحصل على IL لهذا الشكل

٧- $IL\ Y_A = IL\ Y_{A0} + Y_A\ IL\ Y_B$

المطلوب ← ، main sys على (نضع 1t على A) ، $IL\ Y_{A0}$ على (مكان B) ، → معلوم

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I.L ⟶ frame

-١ نفصل العدد الزائد

-٢ نختار ال main sys الغير محدد

-٣ نرسم B.M.D نتيجة الحمل ع ال main sys المحمل

-٤ نجيب $\delta_{11} = \int \frac{M_1^2}{EI}\, dL$

-٥ نشيل رجل الفريم

-٦ نحول conj

-٧ نوجد ال M عند كل المفاصل

-٨ نحسب ال δ_{11} ع كل المفاصل

فنحصل ع ال I.L عند مكان القوة على ال main sys

-٩ $I.L\ y_A = I.L\ y_{A_i} + y_A \cdot I.L_x$

المطلوب ← $I.L\ y_A$

$I.L\ y_{A_i}$ ← ع ال main sys نضع 1 ع A

y_A ← قيمة رد الفعل عند A ع ال main sys

$I.L_x$ ← من الخطوة السابقة

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I.L → Beam - truss

- نقطع في منتصف الـ truss و ذلك لعمل ال main sys
- نرسم $M_1 \rightarrow B.M.D \rightarrow beam \rightarrow EI$

  $N_1 \rightarrow N.F.D \rightarrow beam \rightarrow EA_{beam}$

  $F_1 \rightarrow force \rightarrow truss \rightarrow EA_{truss}$

  نتيجة وجود 1t في مكان القطع
- نجيب $\delta_{11} = \int \frac{M_1^2}{EI} dL + \int \frac{N_1^2}{EA} dL + \sum F_1^2 \, L/EA_{truss}$
- نشيل الـ truss
- نحول لـ conj
- نوجد م عند كل النقاط
- نقسم على δ_{11} عند كل النقاط
- نحصل على IL من النقطة مكان القطع → IL_{F_1}
- $IL_{F_2} = 0.75 \; IL_{F_1}$

  $IL_{F_3} = -1.25 \; IL_{F_1}$

  $IL\,Y_A = IL\,Y_{A_0} + Y_A \cdot IL_{X_1 (F_1)}$

  ↓ (Y_A)

  رد الفعل عند A
  عند وضع 1t
  عند القطع

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Course Name : Structural Analysis (2)		Zagazig University Faculty of Engineering	**Mid Term Exam**	
Course Code :			**Date**	: 7-4-2009
Level : Second Year Civil			**Time**	: 1.30 Hour
Department : Structural Engineering			**No. of pages**	: 1
Term No. : 2			**No. of Questions**	: 3

Solve As You Can

Problem No. (1)

For the shown continuous beam in fig.(1), using three moment equation method

1. Draw B.M.D and S.F.Ds
2. Find deflection at B due to given loads.

K_B=10 t/cm EI=10000 t.m^2

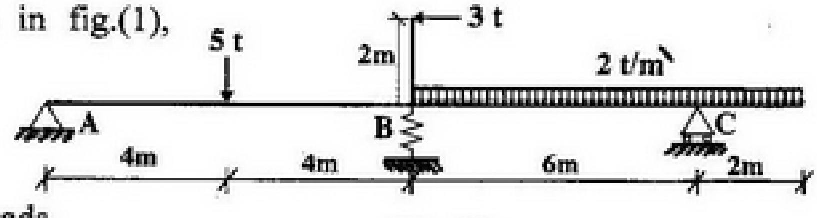

Fig.(1)

Problem No. (2)

For the shown frame in Fig. (2), using three moment equation method, draw B.M.D, S.F.D and N.F.Ds due to given loads.

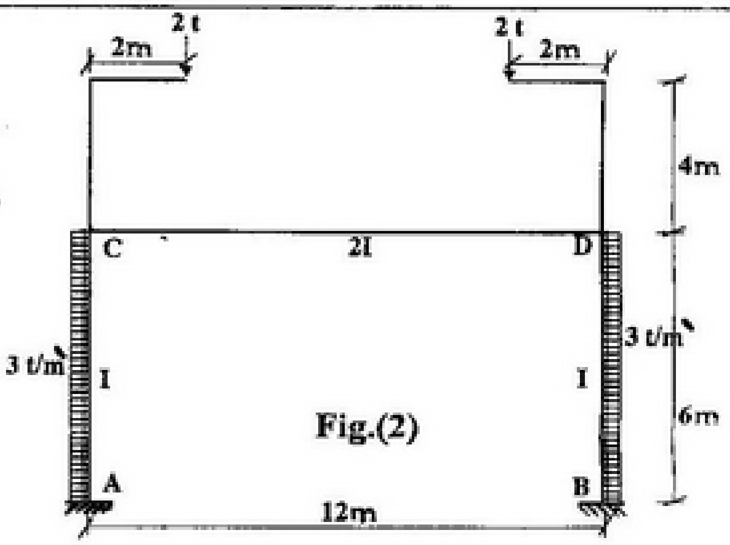

Fig.(2)

Problem No. (3)

For the column **AC** showing in Fig. (3), calculate the maximum value of the concentrated load **P** if the column properties:

Section of column is BFI NO. 36

Steel 37 σ_{pc}=1.1 t/ cm^2

E= 2000 t/ cm^2 & A=190 cm^2,

I_x = 45000 cm^4 & I_y = 10800 cm^4

$\lambda = \frac{l_k}{i} \geq 104$ $\sigma_{pb} = \frac{6000}{(\lambda)^2}$

$\lambda < 104$ $\sigma_{pb} = 1.1 - 0.00005(\lambda)^2$

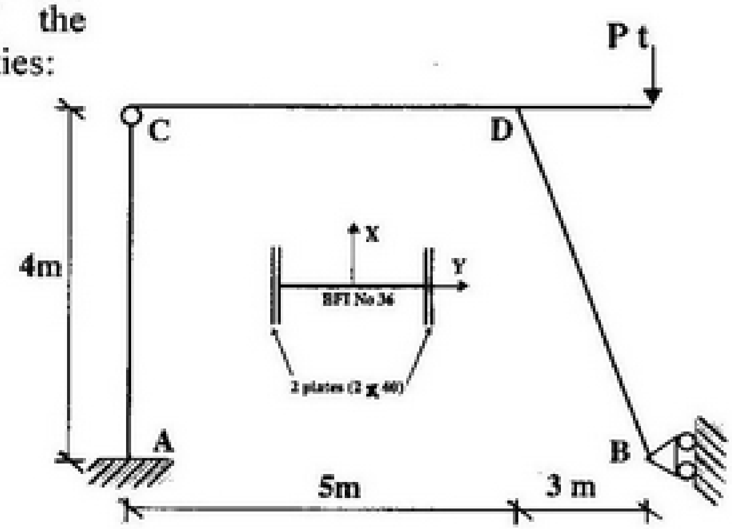

Fig.(3)

Prof. Dr. Sayed Abd-El Salam Prof. Dr. Osman Shallan

Dr.Hanaa El- Sayed

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titanic_ship1912@yahoo.com

Course Name : Structural Mechanics (2)		**Final Exam**	
Course Code :		**Date**	: 24-5-2009
Level : Second Year Civil		**Time**	: 3 Hour
Department : Structural Engineering	Zagazig University	**No. of pages**	: 2
Term No. : 2	Faculty of Engineering	**No. of Questions**	: 6

SOLVE AS YOU CAN

Problem No. (1) *(10 marks)*

Figure (1) shows a statically indeterminate structure, using the three moment equation method,

a) Draw **B.M.D., N.F.D. and S.F.Ds.**

b) Compute the rotation at **B** due to given loads

(EI = 10000 t.m²)

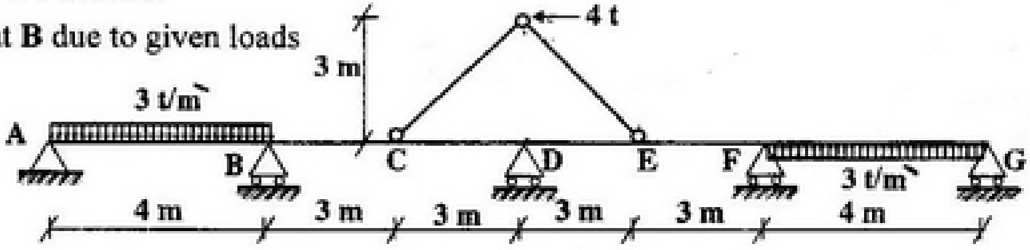

Fig. (1)

Problem No. (2) *(10 marks)*

Figure (2) shows a statically indeterminate structure, using the three moment equation method, draw the **B.M.D., S.F.D. and N.F.Ds.** due to:

1. **Given loads**
2. **Settlement at B=3cm**

(EI = 10000 t.m²)

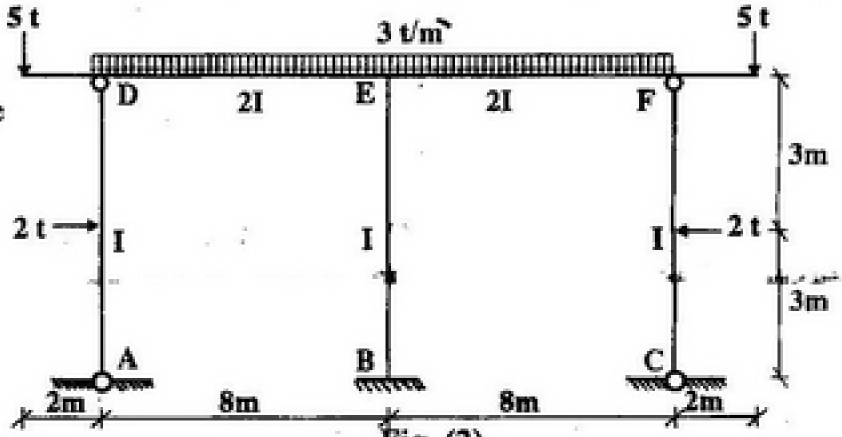

Fig. (2)

Problem No. (3) *(15 marks)*

For the steel column **(AC)** shown in Fig. (3), Steel37

1) **Determine the maximum permissible load P.**

2) **Compute the Euler's critical load and the factor of safety against buckling.**

3) **Drive the formula of buckling length.**

The cross section of the column is BFI No30

$E = 2000\ t/cm^2$, $A = 154\ cm^2$,

$I_x = 25760\ cm^4$, $I_y = 9010\ cm^4$

$\sigma_{pt} = 1.2\ t/cm^2$, $\sigma_{pc} = 1.1\ t/cm^2$

$\sigma_{pb} = \frac{6000}{(\lambda)^2}$ for $\lambda = \frac{l_b}{i} \geq 104$

$\sigma_{pb} = 1.1 - 0.00005(\lambda)^2$ for $\lambda < 104$

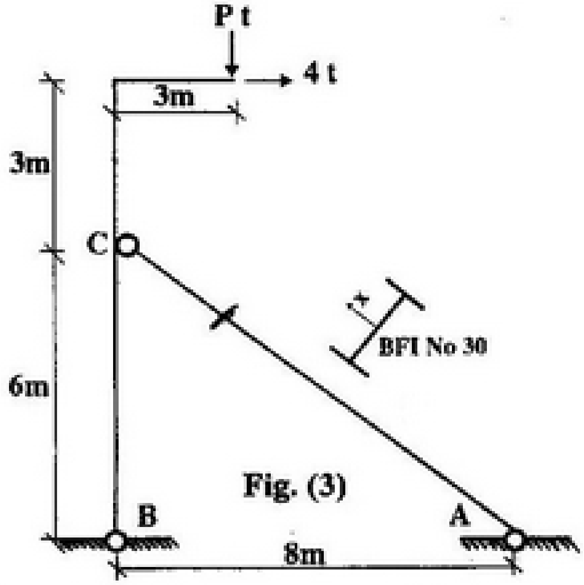

Fig. (3)

اقلب الصفحة من فضلك

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Problem No. (4) *(10 marks)*

For the shown statically indeterminate frame in Fig. (4), calculate and draw the influence lines for Y_A, X_A, Q_D, Q_n and M_n.
Also, find the maximum values for M_n due to 2t/m̀ dead load and 3 t/m̀ live load

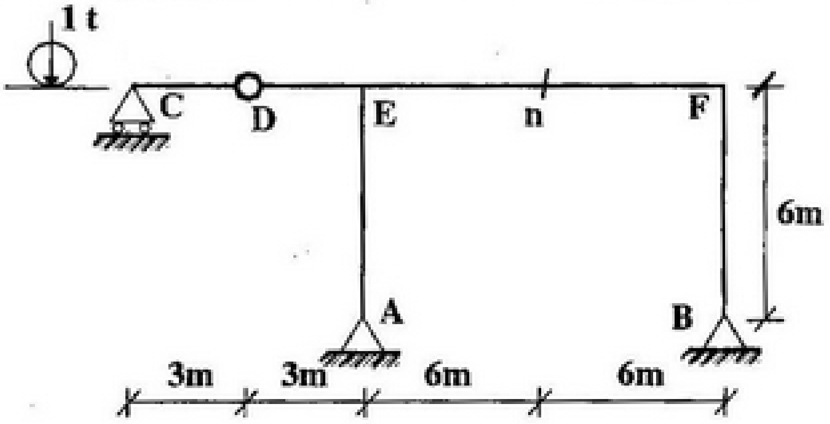

Fig. (4)

Problem No. (5) *(10 marks)*

For the shown statically indeterminate trussed beam (Fig. 5), calculate and draw the influence lines for Nm, Q_m and M_m.

EI_b = 20000 t.m^2

EA_b = 80000 t

EA_{links} = 40000 t

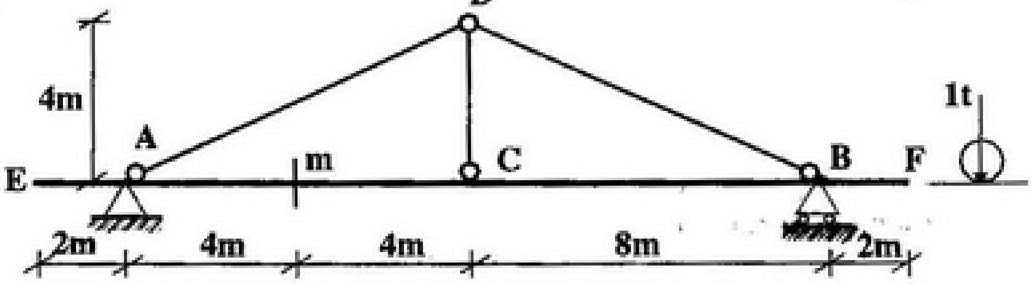

Fig. (5)

Problem No. (6) *(10 marks)*

a) For the structure shown in figure (6-a), without calculations, sketch S.F.D., N.F.D., B.M.D., the elastic curve, and the main steel reinforcement.
b) For the structure shown in figure (6-b), without calculations, sketch the influence lines for Y_D, N_G, N_H, M_F, M_A and Q_E.

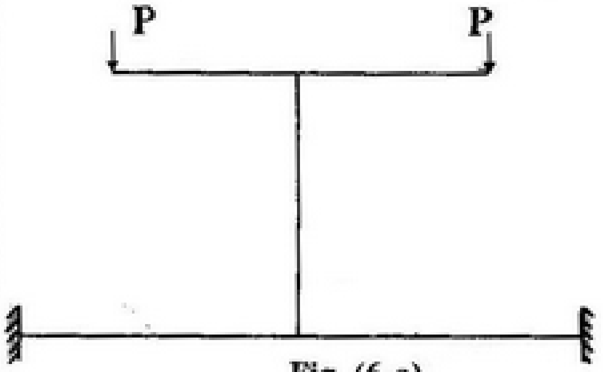

Fig. (6-a)

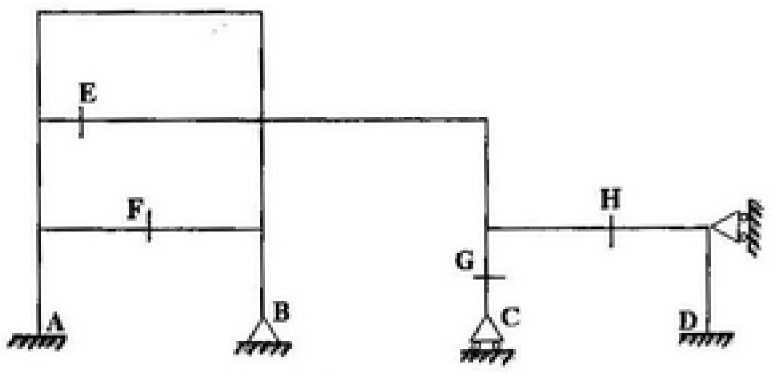

Fig. (6-b)

Prof. Dr. Sayed Abd-El Salam

Prof.Dr. Osman Shallan

Dr. Hanaa Elsayed

scanner by : mahmoud ashraf
titanic_ship1912@yahoo.com

scanner & modified & upload
by
Mahmoud Ashraf

contact info
titanic_ship1912@yahoo.com